AN INVENTORY OF INFORMATION ON THE UTILIZATION OF UNPROCESSED AND SIMPLY PROCESSED SOYBEANS AS HUMAN FOOD

On Contract AID AG/TAB-225-12-76

SUBMITTED TO

THE AGENCY FOR INTERNATIONAL DEVELOPMENT
DEPARTMENT OF STATE
WASHINGTON, D.C.

BY

NORTHERN REGIONAL RESEARCH CENTER
AGRICULTURAL RESEARCH SERVICE
DEPARTMENT OF AGRICULTURE
PEORIA, ILLINOIS 61604

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PREFACE

Inadequate food consumption and poor quality foods for the people of many less developed countries (LDC) have contributed to their high mortality, poor mental as well as physical growth, and general deterioration in the quality of life; in turn, the economic growth of these countries is inhibited. Thus, the lack of low-cost nutritious foods is a basic link in a cycle of poverty and primitive existence.

To provide low-cost and highly nutritious foods for LDC populations, the U.S. Agency for International Development (USAID) supports the approach of introducing soybeans for human consumption. Accordingly, a project to promote soybeans as a food staple among the rural poor in a selected LDC and to develop methods for introducing unprocessed or simply processed soybeans as a direct food for low-income segments of the populations of other LDC's was initiated. This review, an inventory of information on the utilization of unprocessed and simply processed soybeans as human food is a part of that project; its primary purpose is to reveal the state-of-the-art of food uses of soybeans and information on the pattern of soybean consumption around the world. Barriers affecting the use of soybeans as food are identified and an indication of needed research or development work to overcome such barriers in developing countries is included.

H. L. Wang, G. C. Mustakas, W. J. Wolf,
L. C. Wang, C. W. Hesseltine, E. B. Bagley

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INTRODUCTION

The soybean, a native of China, is perhaps one of the world's oldest crops. No one knows how long ago man started to cultivate soybeans. Ancient Chinese literature reveals that soybeans were cultivated and highly valued as a food long before written records were kept and, for many centuries, their cultivation was confined to Asian countries. On a small scale, soybeans were grown in Europe as early as the 1700's and in the United States in the 1800's. Not until the 1930's did the United States begin to produce soybeans as a commercial crop and, since then, the phenomenal growth is history. Today, the United States leads the world in soybean production with 1.5 billion bushels in 1975 (41,406,000 metric tons), while in the same year, China, the chief soybean-producing country in Asia, produced only 366 million bushels (10,000,000 metric tons).

Traditionally, soybeans have been used in the Orient as food. To a great extent, they have provided the Asian population with needed protein since ancient times. In the United States and Europe, soybeans were used as a forage crop through the nineteenth century. Since then, soybeans became valued as a source of edible and industrial oil and as defatted meal for animal feeds. Soybeans as food have never been well accepted by Westerners.

People outside the Orient have had the idea that soybeans are not suitable for human food. Problems encountered in using soybeans for foods include: antinutritional and flatus factors, beany flavor, disagreeable taste, and difficulty of cooking. These problems are not really unique to soybeans, but rather are common to many beans and pulses widely consumed around the world. Undoubtedly, cultural traditions dictate the food habit, but the inherent aversion of people to anything new also curbs the popularity of soybeans outside Asia. Soybeans are scarcely known to people in many areas of the world. They know nothing about the method of cooking soybeans and detect a peculiar flavor and taste. Because of their high-fat and low-carbohydrate content, lack of starch, and compact texture, soybeans do not cook as soft or as readily as many other beans. However, if cooked properly, soybeans do not require much longer cooking time than the other beans, and they are very palatable. Therefore, with some education and promotion, soybeans should easily be included in everyone's diet the same as other beans.

Soybean cooking is a fine art in the Orient. Elaborate fermentation methods as well as many other simple processes have been developed to make a great variety of fresh, dried, and fermented products. The majority of products have been made at home or in family-operated shops. Details of methods are usually kept as a family secret. Consequently, those foods, and the simple technology of making them, are not widely

known or adopted outside the Asian population. In recent years, industrialization has been introduced into the major cities of Asia, but the fine household art of making soybean food products remains active in small towns, or in other areas around the globe to which Orientals have emigrated. Today, millions of Oriental people still enjoy and rely upon soybean foods prepared by methods developed many centuries ago.

Because of the increasing awareness of the nutritional value of soybeans, and the shortage or nonexistence of animal protein in many areas of the world, soybeans are being used today in ever-increasing amounts in a wide variety of food products, and perhaps by more people than ever. This literature survey attempts to reveal the state of the art of worldwide utilization of soybeans as food. Emphasis will be placed on unprocessed and simply processed soybean foods used in the home and at village levels.

The survey, which was mainly derived from the files of Northern Regional Research Center scientists, covered existing literature as well as information obtained from contacts with scientists from various countries, institutes, industries, and voluntary agencies; visits to other countries; and first-hand know how. To supplement and up-date this information, an on-line literature search was made in AGRICULA (formerly CAIN) data base using subject key words as well as key words of voluntary agencies and international organizations; letters were sent to individuals, government agencies, and educational institutions of concerned countries.

Sources of information on soybean production are many: Foreign Agriculture Service (FAS), and Economic Research Service (ERS) of USDA; Food and Agriculture Organization of the United Nations (FAO); International Soybean Program at the University of Illinois (INTSOY); American Soybean Association; and responses from the individual countries. However, production figures from different sources often do not agree, and in some instances, the difference is severalfold.

There are two main sources of information on soybean consumption: national food balance sheets and dietary surveys. However, in many food balance sheets as well as dietary surveys, edible beans are reported in the category "pulses, nuts, and seeds," "pulses," or "dry seeds." This, perhaps, indicates that soybeans or any other beans individually are insignificant in quantity in those countries. Dietary surveys often cover only limited groups, not always representative of countries as a whole. The data on production and consumption, therefore, are less complete and less accurate. Hopefully, they will throw some light on the extent of production and consumption of soybeans in a given country.

HOME AND VILLAGE TRADITIONAL SOYBEAN FOODS

BY COUNTRY

SOYBEAN FOOD USES AND PRODUCTION IN ASIA

Soybean foods are common in the Asian countries, but they are most popular in China, Japan, Korea, and perhaps Indonesia. Because of their long history, the Chinese have had a great influence on the use of soybean foods. As a result, many soybean foods from different countries are similar but the details in preparing and serving may vary. Some of them are still unique to one particular area or country.

In Asia, soybeans are all classified as edible. To make the beans as palatable as possible, many methods have been devised. In addition to whole cooked soybeans, processed soybean foods consumed in Asia include soybean milk, many types of soybean curd, soybean sprouts, soybean protein and oil film, soybean flour, soy sauce, bean paste, soybean cheese, tempeh, natto, fermented black beans, and perhaps others. Some are flavoring agents and others are staples. Many are simply made and some are made by complicated fermentation processes. However, all of them are versatile and can be served in endless ways.

Since information was gathered from many sources, and variations in the procedures of making and serving any one food frequently occur, even in the same country, no attempt has been made to describe each or any particular process, nor to specifically credit the source of the information. Rather, a selection of relatively simple and fundamentally sound processes with significant variations and adaptations will be presented.

Soaking Dry Soybeans

Regardless of the process used and the end product desired, the first and most important step in making soybean foods from dry soybeans in the Orient is to thoroughly soak the beans. The soaking process has long been believed to reduce the cooking time as well as to increase the wholesomeness of the product. Recent scientific findings have supported this belief. Since the soaking process is commonly practiced with little variation, a general description of this process seems to be justified.

For convenience, one usually starts to soak the beans in the afternoon or evening for the following day's use. The beans are rinsed several times with fresh water and rubbed with the hands or stirred vigorously with a paddle. The water is then poured off. The clean beans are allowed to soak in an excess amount of water, i.e., 1 cup of beans to 3 cups of water. Depending on the air temperature, the soaking time may vary from several hours to overnight, in summer 6-7 hours and in winter 24 hours. Overnight soaking, however, is widely used. On a hot summer day, several changes of water during soaking are desirable to prevent bacterial growth. Under controlled laboratory conditions, we found that beans reach maximum water absorption after soaking at 20°C for 18 hours, or at 28°C for 8 hours. Thoroughly soaked beans usually weigh about 2.2-2.4 times their original weight depending on the variety of beans, or slightly less than 3 times their original volume. The soaked beans, after draining and rinsing, are ready for use.

If soaked and dehulled soybeans are needed, the dehulling can easily be accomplished after soaking by rubbing the beans against each other with the hands. The seedcoats, freed from the beans by rubbing, can be floated away with water. In Indonesia, as well as in some other areas, the seedcoats are sometimes removed by placing the soaked soybeans in a bamboo basket at the edge of a river and troeding on them by foot so that the loose seedcoats float away with the streaming water.

Some prefer to boil the beans for 1 minute at the beginning of the soaking, and then let them soak overnight before dehulling. This procedure will facilitate the removal of the hulls.

In Thailand, soybean foods are relatively new and the natives are not acquainted with the taste. They prefer to soak soybeans in a sodium bicarbonate solution to reduce the beany flavor. Recent published results (Kanda et al., 1976) indicate that boiling in 0.2% sodium bicarbonate solution for 5 minutes does, indeed, decrease the beany flavor.

In China

Tou Chiang (Soybean Milk)

Tou Chiang is said to have been originated by a Chinese philosopher long before the Christian era. Because of its appearance and consistency, resembling that of dairy milk, tou chiang is generally known as soybean milk to the people outside of China. Tou chiang has a subtle milk sweetness and a strong characteristic flavor liked by practically all Chinese. The cafe specializing in tou chiang often has an open pot of boiling tou chiang in the front of the shop to lure customers.

Preparation

Materials:--Soybeans and water. While any variety of beans may be used, varieties that have uniform size, light color, thin seedcoat, and high protein are preferred.

Equipment:--Soaking containers, cooking pots, cloth bag, cheese cloth lined strainer or fine screen for filtration, and efficient grinder.

In China, a stone mill is generally used for grinding. The mill consists of two pieces of flat, circular stone with ridgelike grooves on one side of each stone. One stone is put on top of the other with rough sides touching. The top stone can be turned around by hand against the lower one. The beans and water are fed through a hole near the edge. The fluid that flows out between the stones is run into a container. In these days, motor driven mills with vertically mounted stone wheels are also used in small shops.

In the laboratories or at home, we have found that electric blenders or liquifiers, such as Waring Blendors, are convenient to use for producing small quantities of milk. Other automatic food grinders, inexpensive burr-type feed grinders, and stone mills used by corn starch manufacturers in this country are useful (Chen and Chen, 1962).

Procedures:--Making tou chiang is a rather simple process and has been described by several investigators (Piper and Morse, 1923; Chen and Chen, 1962; and Wang, 1967). In general, these procedures are very similar, and they can be carried out either at home or at village levels as well as in a modern factory.

The beans (1 rounded cup, approximately 200 g.) are first washed, soaked, and drained as described under "Soaking Dry Soybeans." The soaked beans (approximately 3 cups or 500 g.) are ground with a stone mill while a small stream of water is added. Or the beans can be blended with a small amount of water in a Waring Blendor for 2 minutes at high speed. The ground mass is placed in a cooking pot and more water is added to make a water-to-bean ratio of 8:1 based on the weight of the dry beans (amount of water needed after soaking, 1,300 ml.). The ground mass is stirred for a few minutes and heated to boiling with constant stirring to prevent scorching. It is often necessary to skim off the froth over the surface to prevent sudden boiling over. The cooked ground mass is strained through a cloth bag or double layered cheese cloth. The tou chiang or soybean milk (approximately 1,000 ml.) passes through the bag and leaves the insoluble residue (tou cha or soybean pulp) behind.

In many shops, the ground soybean mass is heated in a drum using steam from a coal-heated boiler. It is then run into a device similar to a Buchner funnel but fitted with a fine metal screen. The device is set over a big barrel into which the soybean milk filters.

To produce tou chiang that has a smooth mouth feel and fine-textured consistency, it is important to feed the beans slowly and with a small amount of water during grinding. Grinding with a large amount of water often results in a ground mass of coarse texture which, in turn, yields low-quality milk.

A water-to-dry bean ratio of 10:1 is also commonly used in China. The ratio is not a critical factor in making tou chiang; however, a ratio higher than 10:1 will result in a product having low protein content without increasing total protein recovery. On the other hand, a ratio lower than 8:1 may yield milk having a high protein content, but the total protein recovery might be low. From Chinese experience, ratios of 8:1 to 10:1 are most suitable.

Some tou chiang makers prefer to filter the ground mass before heating, even though it is much easier to filter after cooking. Perhaps the extra fuel cost of cooking is considered to be more important than time.

In recent years, various procedures have been developed to reduce the beany flavor of soybean milk (Kanda et al., 1976; Kon et al., 1970; Nelson et al., 1976; Wilkens et al., 1967). The simplest ones are to grind the beans with boiling water or to boil the beans in dilute sodium bicarbonate solution before grinding. The heating process, however, may denature the soybean protein and thus reduce the protein solubility.

Byproduct:--The only byproduct from making tou chiang is the insoluble residue known as tou cha, which has a very high nutritional value (Hackler et al., 1963; Hackler et al., 1967). It is commonly used as animal feeds, but it is also eaten by people.

Composition and properties

The composition of tou chiang will vary with the bean variety used and with the preparation method (Lo et al., 1968a,b; Wilkens and Hackler, 1969). In general, it is low in fat, carbohydrates, calcium, phosphorus, and riboflavin, but high in iron, thiamin, and niacin in comparison with cow's milk. Tung and his coworkers (1961) give the following composition of tou chiang sold in Taiwan: water, 94 g.; protein, 3.3 g.; fat, 0.9 g.; carbohydrates, 1.4 g.; ash, 0.3 g.; calcium, 12 mg.; phosphorus, 40 mg.; iron, 0.7 mg.; thiamin, 0.04 mg.; riboflavin, 0.02 mg.; and niacin, 0.2 mg.; per 100 g. of tou chiang.

The properties of tou chiang are quite similar to those of animal's milk. Acids and inorganic salts will coagulate the protein. Like cow's milk, touchiang can also be fermented by some *Lactobacillus* bacteria to yield acid milk and yogurt-like product.

Ways of serving

Direct uses:--Traditionally, tou chiang is made fresh daily and sold on the street or in small cafes. Even though the tou chiang process can be easily carried out at home, it is not commonly done because tou chiang is readily available commercially.

Tou chiang is served hot after boiling and as part of the breakfast. Some prefer it flavored with sugar, while others have a fancy for a salty taste achieved by addition of soysauce (chiang yu, a fermented soybean product containing 16-18 percent salt), a little green onion, a dash of sesame oil, and even little salt-pickled vegetables.

In Chinese tradition, tou chiang has been consumed by adults rather than by children. A typical tou chiang consumer, perhaps, is a middle class office worker or college student who has enough education to know the nutritional value of tou chiang, and who also has extra cash. On his way to work in the morning, he will have a bowl (8 oz) of tou chiang and some breadlike food for his breakfast.

Tou chiang is more popular in cities than in the rural areas. Not because the people in the rural area do not like tou chiang, but, more likely, because they do not believe in spending their time or hard cash on a bowl of "watery stuff."

With increasing awareness of the nutritional value of soybeans, tou chiang is more popular than ever. In Taiwan, one can find a tou chiang stand or cafe on almost every street corner. Tou chiang has also been bottled and sold as a cold drink. Its popularity in China, however, is limited.

To increase the nutritional value of tou chiang for infant feeding, Dr. Huang and his coworkers at the College of Medicine of National Taiwan University, Taiwan (Huang et al., 1976) suggested enriching soybean milk with partially autolyzed egg. In our communication with Dr. Huang, he indicated that the idea of adding an egg to a bowl of tou chiang is widely practiced in Taiwan. However, this egg-soybean milk is usually consumed by adults, to a lesser extent by children, and is only infrequently given to infants.

Indirect uses:--Many soybean foods which are more important and popular than tou chiang itself are made from tou chiang--those foods will be discussed in the later sections.

Suggested uses:--Tou chiang can be used the same way as cow's milk in many Western recipes. It can also be made into yogurt--or acid milk-type products. First it is heated to boiling, mixed with sugar (5 percent), poured into a container, allowed to cool, and then inoculated with pure culture (Wang et al., 1974; Kanda et al., 1976), yogurt, or commercially available yogurt starter. The container is then covered and kept in a warm place until yogurt consistency is obtained, usually overnight depending on the temperature. In our laboratory, we incubated the inoculated soybean milk for 20 hours at 37°C.

Yogurt made from soybean milk is best when served cold, or it can be mixed with equal parts of water and served as a sour cold drink.

Tou Fu (Soybean Curd)

Tou fu is closely associated with tou chiang (soybean milk), because the initial step in making tou fu is to make soybean milk. When a mineral salt or acid is added to soybean milk, coagulation occurs which is similar to cottage cheese produced from dairy milk. When the coagulated mass is allowed to drain, the result is a soft white curd called "tou fu" by the Chinese and soybean curd by the people from the Western world.

Tou fu has a very bland taste and is white or grayish white. It has a soft but firm texture with the consistency of cream cheese. Traditionally, tou fu is made daily and sold in the form of a wet cake. The size of the cake may vary, 10 X 10 X 3 cm. being a common size.

Tou fu, perhaps, is the most important soybean food in the Orient. It has much the same importance to the people of the Orient that meat, egg, and cheese have for the people in the West.

Preparation

Manufacture of tou fu started during the era of the Hang dynasty; Liu An (179 B.C.-122 B.C.), King of Wainan, invented the method of preparation. Centuries later, numerous procedures of making tou fu have been described (Adolph and Kiang, 1920; Chen and Chen, 1962; Chin and Van Duyne, 1961; Piper and Morse, 1923; Shurtleff and Aoyagi, 1975;

Smith _et al_., 1960; Wai, 1964; Wang, 1967); however, the underlying principle for making tou fu is still based on the simple one invented by Liu An. The details of these procedures may vary to some extent, just as any household art may vary from one family to another, but in general they are very similar.

Materials:--Soybeans, water, and coagulants. Any variety of soybeans may be used for making tou fu; however, yield, color, and texture of tou fu vary with the variety (Piper and Morse, 1923; Smith _et al_., 1960). Original protein and oil content of the beans is a factor in yield as well as in the final protein and oil content of the tou fu. In general, Chinese prefer beans having high protein content, uniform maturity and size, thin seedcoats, and a bright, light color, which are essentially the same as required for making soybean milk.

The most commonly used precipitating agents or coagulants are powdered gypsum (a mixture of calcium sulfate and magnesium carbonate) and yen-lu (the concentrated liquid obtained in the manufacturing of salt from sea water, containing mainly magnesium sulfate and magnesium chloride). Since the Chinese diet is low in calcium, it is apparent that the most desirable coagulant would be calcium salts: calcium sulfate, calcium chloride, calcium lactate, calcium gluconate, and calcium citrate (Wai, 1964). Acids, such as citric or vinegar have also been used, but not commonly in China.

Equipment:--In addition to the equipment required for making soybean milk, as described under tou chiang, square wooden boxes about 4-5 cm. deep are used to press and mold tou fu. The boxes should be equipped with small holes or slits, and lined with cloth so that the excess whey can be drained off, and the curd is formed into the size of the box.

Procedures:--The first step in preparation of tou fu is to make tou chaing (soybean milk as previously described). Next, the protein is precipitated by a coagulating agent and then placed into a molding box to form a cake.

About 1,000 ml. of tou chiang obtained from 1 cup of dry beans is brought to a boil, and 3.5 g. of $CaSO_4 \cdot 2H_2O$ suspended in 20 ml. hot water is slowly added to the hot milk (70-80°C). In many shops, where ground bean mass is cooked before filtration, no cooking is applied to the resulting soybean milk before the addition of the coagulant. Since tou fu is frequently eaten without further cooking, we recommend boiling the milk for 20-30 minutes before adding the coagulant to increase the nutritional value and also to lessen the beany flavor. During cooking, constant stirring is necessary to avoid scorching. Steamers or double boilers are very convenient for this purpose.

The coagulation of soybean protein by the addition of a salt is the most difficult step in making tou fu. The right amount of salt and the kind of salt used are two important factors necessary to attain a satisfactory curd. We recommend 3-4 g. of $CaSO_4 \cdot 2H_2O$ per 1 liter of

milk obtained from 1 cup of dry beans. Shurtleff and Aoyagi (1975) suggest the use of 3 tablespoons magnesium chloride, calcium chloride, calcium sulfate, or magnesium sulfate for the amount of soybean milk obtained from 8 cups of soybeans (ratio of water to beans being 8:1).

The kind of salt used also affects the quality of the tou fu. Calcium sulfate seems to be superior to other calcium or magnesium salts, because calcium sulfate coagulates the protein slowly to give the most gelatinous type of precipitation and the smoothest texture.

The salt should first be dissolved or suspended in hot water and then added to the hot milk (70-80°C) with gentle mixing by a paddle or scoop. The addition of an insufficient amount of salt or the addition of the salt too quickly not only causes incomplete precipitation but also results in a turbid suspension, which makes separation of the whey from the precipitated protein difficult. On the other hand, too much salt makes the tou fu too hard, which is not liked by most Orientals.

Satisfactory and complete curd formation is indicated by the slow aggregation of the small curd into a large mass which gradually settles to the bottom of the container, and change of the milk into a light yellowish, clear liquid. A sudden flocculation usually means excess precipitating agent. With close observation and some practice, one can easily achieve this most difficult step of making tou fu.

After the curd settles, the whey (the supernatant) is partially removed, and the curd is transferred to a wooden box lined with coarse filter cloth. A box of 12 X 12 X 5 cm. with small holes or slits in the sides and at the bottom is a convenient size to handle the quantity of curd made from 1 cup of soybeans. The ends of the filter cloth are folded over, and a board placed upon it. It is then subjected to pressure from the top with stones or other weights of about 500 g. to squeeze out the whey. When draining has stopped, the cake, which should be solid enough to stand handling, is ready to be removed from the box. From 1 cup of soybeans, 450 to 500 g. of tou fu with a moisture content of 85 percent is made. The amount of curd, the weight of pressure, and the pressing time will affect the hardness of the tou fu. Large batches of tou fu can be made by using the same procedure, and the same simple and inexpensive but larger equipment. When pressing curd, the wooden boxes can be stacked and pressed under a weighted lever.

Byproducts:--Tou cha (the residue from making soybean milk) and whey are the only byproducts from tou fu manufacture. Both are used for animal feeding. Tou cha is also used for food.

Composition

The composition of tou fu may vary depending on the bean variety used and the method of preparation. The following is the composition of tou fu made in Taiwan, as reported by Food Industry Research and Development Institute, Hsin Chu, Taiwan (1971)): water, 86.3 g.; protein, 7.3 g.; fat, 3.5 g., carbohydrates, 2.3 g.; fiber, 0.3 g., ash, 0.7 g.; calcium, 95 mg.; phosphorus, 106 mg.; iron, 2.8 mg.; vitamin B_1, 0.05 mg.; vitamin B_2, 0.03 mg.; and niacin, 3.8 mg. in 100 g. of tou fu.

Ways of serving

Because tou fu is rich in protein, fat, and minerals, it is known in China as "meat without bones," even though tou fu, as used in the Orient, has a soft, cream cheeselike consistency that is quite different from meats. However, a variety of products processed from tou fu that have less moisture content and a more chewy texture are available.

Tou fu is consumed almost daily by everyone in China--rich and poor, young and old. No report has been given of the amount of tou fu consumed by each person daily, but a figure of 3-4 oz. seems to be reasonable.

Tou fu is usually made, sold, and eaten the same day, although it can be kept in cold water for a couple of days when the weather is not too hot, and for as long as 2-3 weeks in the refrigerator with changes of water. Tou fu when fresh is a rather tasteless product, but it can be made into a great variety of delicious dishes.

Without cooking:--A delightful way to serve tou fu without further cooking is simply to serve it with the addition of soysauce, sesame oil, green onion, or hot oil if one has a taste for hot food, or with any other spices or flavoring agents one prefers.

Boiling:--Tou fu is frequently used in soups with vegetables, such as chicken broth with tou fu and peas; but it is used with any soup stock and vegetables depending on availability and preference. Cooking time for tou fu is short, just a few minutes but not critical.

Tou fu is also served by boiling and then dipping into one's favorite sauce. It is the key ingredient in huo-kuo (firepots) which is a one-pot cookery containing the entire meal similar to Westerner's fondue cookery.

Quick stirring:--Using a small amount of oil in a heated skillet, cook slices of tou fu until both sides are brown. Add soy sauce or other flavoring agents as desired, and serve hot. Sometimes, sliced pork or beef are first browned and then mixed with tou fu.

Simmering:--Shredded pork or beef are cooked in a little hot oil with constant stirring. Add hot bean paste and a small amount of water, then bring to a boil. Add small cubes of tou fu, salt, and soy sauce to taste. Cover and simmer for about 5 minutes.

Shrimp is also cooked with tou fu in the same manner.

Steaming:--Tou fu cakes are stuffed with flavored ground meat or shrimp and then steamed. Tou fu is also steamed just with flavoring agents, such as soy sauce or sufu (fermented tou fu).

Stewing:--Bean curd cooked in an earthen pot is a common way of eating tou fu in the Szechuan region. Place cut up chicken, pork, ham, dry sea foods, vegetables, mushrooms, tou fu, or any other foods one prefers in the earthen casserole. Add salt and soup stock and simmer over low heat until served.

Chinese dishes are usually cooked meats or sea foods together with vegetables or tou fu, so that the vegetables and tou fu are enriched with the meat flavor. Here, tou fu is shown to be cooked in all the major ways available in China and its versatility is evident. With a little imagination, tou fu can be used in the national cuisine of countries around the world.

Processed Tou fu Products

Tou fu nao, tou fu kan, chien chang, yu tou fu, and tung tou fu are different forms of tou fu. These products, with different degrees of hardness and water content, are made from tou fu by applying various amounts of pressure when tou fu is pressed at the molding stage. The material and equipment required and the procedure to make these products, therefore, are the same as for making tou fu.

Tou fu nao (Soft curd)

Tou fu nao has a softer consistency than tou fu. It is prepared by adding less than the regular amount of coagulant required for making tou fu, and it is not pressed. The soft custard-like curd looks like thickened soybean milk and is served just like soybean milk. Some prefer to have tou fu nao with sugar, and others like it with soysauce, sesame oil, pickled vegetables, dry shrimp, and even chopped meat.

Tou fu nao is also served as a part of breakfast, but it is not as common as tou chiang.

Tou fu kan (Dry bean curd)

"Kan" in Chinese means "dry," so it is apparent that tou fu kan contains less water than tou fu itself does. When tou fu is pressed under pressure until as much whey as possible is expelled, products with a water content as low as 50 percent can be obtained. The thinner the cakes of tou fu, the drier the products can be made. These products are known as peh tou fu kan (white, dry bean curd) because they are still whitish in color. One can slice this white, dry bean curd into thin strips and use it as noodles in soups, or saute it with meat and vegetables. White, dry bean curds sometimes are immersed into a special vegetable stalk-salt solution which yields a fermented product.

Frequently, white, dry bean curds are simmered in hot strong tea and burnt sugar for a short time, followed by surface-drying over a slow open fire. This brown product is generally known as tou fu kan. Tou fu kan has a chewy, meatlike texture, and also has a special aroma and taste.

There are many variations of tou fu kan. Usually it is further seasoned with soysauce, star anise, pepper corn, or special Chinese five spices powder, and then dried over low heat. All these products can be consumed as they are as a side dish for regular meals or as between-meal nourishment. However, they are frequently cooked with meat and vegetables in sauteed and simmered dishes. Tou fu kan is not as commonly consumed as tou fu, perhaps because it costs more.

Chien chang

This product is formed by pressing thin layers of bean curd between sheets of cloth. The product, which looks like a piece of cloth, can be cut into thin strips and used as noodles in soups. It can also be stewed with meat. Sometimes it is used to wrap ground meat and then cooked.

Chien chang is often rolled into thin rolls, sprinkled with salt, and then packed into a covered bowl. After setting at room temperature for a few days, a natural fermentation takes place which yields a strong-flavored product known as mei chien chang (fermented chien chang). The product is steamed before serving. This fermented product is made at home in some regions.

Yu tou fu (Fried tou fu)

The fresh tou fu with a low moisture content is cut into small squares and deep-fried. Yu tou fu is just another form of tou fu and can be served just like any other tou fu product.

Tung tou fu (Frozen tou fu)

Because of lack of freezing facilities, frozen tou fu is usually consumed only during the winter months. Fresh tou fu is cut into small pieces and exposed to severe weather. After freezing, the structure of tou fu is greatly changed; all the water becomes ice. When the frozen tou fu is thawed, only a network of protein and other solids is present; it looks like a piece of sponge. It is resilient and absorbent. It has a chewy texture which is remarkably similar to that of tender meat.

Frozen tou fu is used in soups or stewed in an earthern pot with meats, sea foods, and vegetables. In general, processed tou fu products are not as frequently eaten as tou fu.

Tou Fu Pi (Protein-Lipid Film):

Tou fu pi is another product closely related to soybean milk or tou chiang. It is the film formed on the surface of soybean milk during heating, just as skin forms in the heating of cow's milk. The cream-yellow film is usually air-dried and sold in the form of sheets, sticks, or flakes.

Preparation

In the preparation of tou fu pi, soybean milk is heated to a boil in an open pan and then maintained at a temperature just below boiling over a low fire. When a film is formed, it is removed from the milk by passing a stick underneath the film surface. The stick with the film is then hung to air dry or to dry over a low charcoal fire (Piper and Morse, 1923). Succeeding films are removed in the same fashion until no film is formed. Piper and Morse (1923) mentioned in their book that the milk from 3 lb. of beans would yield about 30 sheets of tou fu pi. Wu and Bates (1972a) reported that after film formation ceased, the soybean milk remaining contained about 34% protein, 11% total lipid, 28% carbohydrates, and 13% ash (percent dry-basis), whereas the starting milk contained 50% protein, 29% total lipid, 16% carbohydrates, and 6.6% ash.

Frequently, the tou fu maker harvests a few sheets of tou fu pi before adding salt to make tou fu.

Composition

The composition of tou fu pi is not consistent. Wu and Bates (1972a) found that the protein and lipid content of successively formed films generally decreased. The carbohydrate content of the first groups was always the lowest and increased in the subsequent groups. The ash content of the successive groups of films also increased gradually, and was especially high in the last groups. Wu and Bates (1972b) also found that the film is not a compound of fixed chemical composition, since the ratios vary somewhat with the composition of soybean malk processing conditions. In general, they found the film contained 55% protein, 28% total lipids, 12% carbohydrate, 2% ash, and 9% moisture, which is comparable to that cited by Borgstrom (1968), 52% protein and 24% fat.

Even though the moisture content of tou fu pi is low, the shelf life of the product is short because of its high lipid content.

Ways of serving

Tou fu pi or Yuba in Japan is a very popular foodstuff in the Orient; however, it is not eaten daily.

Tou fu pi is quite brittle and is always softened by soaking in cold water before cooking. It can be used in soups or as a sheet for wrapping ground meat or vegetables which are then steamed, simmered, or fried. "Vegetable chicken," a must for a vegetarian's banquet, is made by folding several rehydrated sheets of tou fu pi seasoned with soysauce and other spices, and then steaming and slicing.

Huang Tou Ya (Yellow Bean Sprout, or Soybean Sprout)

Bean sprouts, which are quite popular in the United States, are not made from soybeans; they are sprouts of the mung bean (Phaseolus aureus), tiny green beans. Sprouts grown from soybeans are very popular in China, and are known as huang tou ya which means yellow bean sprouts. They look like mung bean sprouts except that the bean portion (cotyledons) of the soybean sprout is more distinct because of its large size and light yellow color. Soybean sprouts have the same crispy texture as mung bean sprouts and are more tasty. However, mung bean sprouts are more frequently eaten than soybean sprouts because of their cost difference.

Preparation

Materials and equipment:--Soybeans, sprouting container, and cover. Any container equipped with draining outlets is suitable. Bamboo baskets are frequently used and straw mats are used as cover. Clay flower pots available in the United States are also convenient to use at home. Cover the bottom hole of the clay pot with rust-proof screens or cheese cloth to prevent beans from falling through the hole.

Procedures:--It is quite simple to sprout beans at home. There are only a few rules to follow. Beans need enough moisture to germinate, but with too much water the beans may rot and with not enough the beans will not germinate. Germination occurs best in a dark place and at a temperature of about 25°C.

Soybeans (1 cup) are washed and soaked in water overnight. Soaked beans are poured in the sprouting container (10 X 8 inch), rinsed thoroughly, drained well, and covered tightly to keep out the light and to prevent evaporation. The container is then kept in a dark place. The beans must be watered 3-4 times daily by pouring water through the container without disturbing the sprouts. If the room temperature is quite high, the beans should be watered more often. It usually takes from 3-5 days in the summer and almost 2 weeks in the winter for the sprouts to reach full growth. At that time, they can be pulled out from the pot; after most of the seed coats have been washed out, the sprouts are ready for cooking.

Composition

The composition of soybean sprouts as reported by Leung *et al.* (1972) is as follows: moisture, 81.5%; protein, 7.7%; fat, 1.8%; carbohydrates, 8%; fiber, 0.7%; ash, 1.0%.

Ways of serving

Bean sprouts are eaten as a common vegetable throughout the year. However, like many of the other vegetables, they are not eaten daily.

The sprouts are used frequently in soups. Sometimes, they are steamed with salt, oil, and some green onion. They may be used in almost any way that green vegetables are used. They must be cooked, but require only a short cooking time.

Whole Soybeans

There are several ways of using whole soybeans in the Chinese diet, even though usage of whole soybeans as food in China is not as common as that of the other processed soybean products.

Mao tou (Hairy bean, green soybean, or immature soybean)

When soybeans are picked green or picked at three-fourths maturity--pods are greenish-yellow and the beans are large and soft--they are the most delicious and nutritious green vegetable. Standal (1963) found steamed green soybeans to have the highest net protein utilization value among all soybean products investigated in her study: tou fu, natto, green soybeans, soybean sprouts. The composition of green soybeans is as follows (Leung et al., 1972): moisture, 68.2%; protein, 13%; fat, 5.7%; carbohydrate, 11.4%; fiber, 1.9%; ash, 1.9%.

Green soybeans cooked in the pods with salt for 10-15 minutes are good between-meal nourishment. They can also be shelled and cooked like other beans. Chinese like to cook their vegetables with meat, so the shelled green beans are often steamed or sauteed with meat.

Green soybeans are a seasonal vegetable. When they are in season, they take the place of some of the other soybean products and vegetables.

Dry soybeans

Roasting and frying:--Dry soybeans are often roasted over an open fire after soaking and are eaten as a snack, like peanuts are in this country. Some prefer to fry soybeans in deep oil which seems to give added taste. The texture of roasted or fried soybeans is too hard to suit the American's taste, but they have been enjoyed by Chinese for centuries.

Stewing and boiling:--Dry soybeans after soaking are also cooked with pork, similar to "pork and beans" of this country, but with different seasonings, soysauce being the most common one. Cooking time is usually about 2 hours. Longer cooking time may result in a more tasty dish, but soybeans will not cook as soft as other beans because they contain very little starch. Sometimes, soaked soybeans are boiled with soup bones to make a tasty soup. Or they are cooked with bamboo shoots, soysauce, and other spices followed by sun-drying to use as a snack food.

Roasted soybean flour

Roasted dry soybeans are sometimes ground into flour and then mixed with lard and sugar. This mixture is used as fillings for pastry, or to coat the surface of other pastries. Soybean flour as processed in this country is not commonly used in China.

Fermented Soybean Foods

Fermented products such as sufu, tou shih, soysauce, and bean paste, made from soybeans or soybeans with cereals, have been used in China for centuries (Hesseltine and Wang, 1972). Most of the products have a very strong characteristic flavor and are commonly used as flavoring agents. From their experiences, the Orientals consider fermented soybean products as nourishing and easily digestible foods. The Oriental diet consists mainly of rice and vegetables which can be rather bland. The strongly flavored fermented foods not only add taste to the rice-vegetable diet, but also, through stimulating the appetite, contribute nutritional value to people who may otherwise not consume enough food to meet their caloric requirements.

The Chinese developed those processes without the knowledge and the benefit of microbiology and modern technology. Today, many of them are still carried out as natural processes at home. However, some processes, such as soysauce, bean paste (miso), and sufu (fermented tou fu), have been extensively studied, and pure culture fermentation methods have been developed (Hesseltine and Wang, 1972). Since these fermentations require a long period of time and involve a number of complicated steps, their technology is not reviewed in this report.

Production and Consumption of Soybeans

The People's Republic of China produced 10,000,000 tons of soybeans in 1975. The FAO food balance sheets average 1964-1966 (1971) indicated per capita consumption of 6.7 kg. yearly and a total food use of 5,123,000 tons of soybeans per year.

In Taiwan, soybeans are mostly imported; however, on some small areas, the crop is grown which accounts for less than 10% of total soybeans used in Taiwan. Soybean production and imports in Taiwan from 1962 to 1975 are given in Table 1. In general, 85% of the soybean goes into oil, and the remaining 15% is for food use. In 1975, about 93,000 tons of soybeans were used in making tou fu, 30,000 tons for soysauce, and 20,000 tons for miscellaneous food use. The yearly per capita consumption of soybean foods by Chinese in Taiwan is shown in Table 2.

Table 1. Soybean Production and Imports in Taiwan from 1962-1975*

Year	Soybean Production	Soybean Imports	Total Soybean Supply
		1,000 metric tons	
1962	53.0	62.4	115.4
1963	52.6	182.5	235.1
1964	57.6	181.8	239.4
1965	65.7	161.4	227.1
1966	63.3	164.5	227.8
1967	75.2	347.0	422.2
1968	73.0	384.9	457.9
1969	67.1	472.2	539.3
1970	65.2	617.5	682.7
1971	61.0	524.9	585.9
1972	60.2	711.6	771.8
1973	60.6	626.0	686.6
1974	66.9	528.6	595.5
1975	61.9	827.3	889.2

*Source: Republic of China (1975).

Table 2. Consumption of Soybean Foods in Taiwan from 1964-1974*

Year	Soybean Food	Tou fu (80% H_2O)
	kg./capita/year	
1964	1.08	18.75
1965	1.13	20.14
1966	1.12	19.54
1967	1.40	28.50
1968	1.19	23.91
1969	1.87	28.95
1970	2.34	33.34
1971	2.35	32.30
1972	2.61	33.89
1973	2.36	31.30
1974	1.99	32.04

*Source: Chinese-American Joint Commission on Rural Reconstruction (1975).

In Japan

Tofu (Soybean Curd)

Tofu is the most popular soybean food in Japan. It was brought to Japan from China centuries ago by Buddhist Monks who used tofu as a daily diet. Although Japanese tofu is very similar to Chinese tou fu, the Chinese product generally has a firmer texture.

In Japan, tofu is processed into many forms; however, fresh tofu is used in the largest amount and is the starting point for all other types. Fresh tofu is usually made in small shops which process from 100 to 300 pounds of beans daily. In recent years, large plants have begun to mass-produce tofu; each tofu cake (10-1/2 oz.) is water-packed in a polyethylene container, sealed with a sheet of transparent film, and pasteurized by immersion in hot water for 1 hour to give a shelf life of up to 1 week. This tofu is sold in supermarkets and neighborhood grocery stores at a price slightly below that of the tofu made by neighborhood shops.

Preparation

The preparation of tofu and other tofu products in Japan has been described by Smith (1958), Smith *et al.* (1960) and more recently in much detail by Shurtleff and Aoyagi (1975). The basic steps of making tofu and the equipment required are essentially the same as described for tou fu in China. Following is an account for making tofu at a village or community level detailed in the *Book of Tofu* by Shurtleff and Aoyagi (1975).

Materials:--Soybeans, 8 cups; water; solidifiers or coagulants. For subtly sweet tofu use: 3 tablespoons granular magnesium chloride or calcium chloride; or 2-1/2 to 4 tablespoons granular or powdered natural nigari (the mineral-rich liquid remaining after salt is extracted from seawater); or 3 to 8 tablespoons commercially prepared liquid nigari; or 8 cups of freshly collected clean seawater. For mild soft tofu use: 3 tablespoons Epsom salts (magnesium sulfate) or calcium sulfate. For sightly sour tofu use: 1-1/4 cups lemon juice or lime juice, or 1 cup vinegar.

Equipment:--Grinding stones, electric blender, or electric stone mill; cooking pots and lids, pressing sack, a rectangular sack (such as a small flour sack) about 24 inches long and 13 to 15 inches wide made of coarsely woven strong fabric; pressing barrel made of wood or metal having a capacity of 6 to 8 gallons; pressing rack consisting of rods placed across the opening of the pressing barrel with a space of several inches between each rod. Settling boxes for pressing and molding tofu. Use a box of about 10 X 30 X 30 cm. with many holes 1 cm. in diameter in all sides and bottom to allow drainage. The box should be lined with a piece of cheesecloth or other coarsely woven cloth and fitted with a flat lid.

Procedures:--Eight cups of dry soybeans are rinsed and soaked in 1-1/2 gallons of water for 8 to 10 hours, or in cold weather for as long as 15 to 20 hours as described under "Soaking Dry Soybeans;" they are again rinsed well and allowed to drain. Each 2-1/2 cups of soaked beans is blended with 2-2/3 cups of water in an electric blender at high speed for 2-3 minutes or until smooth. The resultant soybean mash (known as go in Japan) is transferred to a large container. This grinding process is repeated until all soaked beans are ground. Pour the combined go into 1 gallon of boiling water and continue to heat the diluted go over high heat, stirring bottom of pot frequently with wooden paddle to prevent sticking. When foam suddenly rises in pot, quickly remove from heat. To filter go, transfer hot diluted go into pressing sack, quickly place pressing rack across the opening of pressing barrel, and set sack on top of the rack. Twist sack closed and put a heavy pressing weight on top of the sack to expel as much soybean milk as possible. Pour another gallon of hot water in the sack to rinse the residue and press again. Bring soybean milk to a boil, stirring bottom of the pot to prevent sticking; reduce heat to medium and continue to heat for 5 minutes. Add 1-1/2 quarts of hot water to the solidifier, and then add the mixture to the hot milk.

It is believed that every tofu maker has his own unique way of adding coagulant. Some stir in a circle and some stir back and forth across the pot; some stir rapidly, some slowly; some add all the coagulant at once, some in two or three portions; some pour in from 6-12 inches above the milk surface, some sprinkle it gently over the surface, and some do both. However, it is the chemical nature and the quantity of coagulant used, not the manner of adding coagulants, that dictate the quality and yield of tofu. After the curd settles for about 8 to 10 minutes after the addition of coagulant, remove portion of clear whey and transfer curds to cloth-lined settling box. Fold corners of the cloth neatly over curds, place lid on top of cloth and set a 4- to 6-pound weight on top for about 5 minutes. Increase weight to about 10 pounds and press for 30 to 40 minutes more or until whey no longer drips from the box. Remove cloth-wrapped tofu from box, allow it to cool for 10 to 15 minutes and then unwrap. Tofu may be served immediately.

Many tofu makers in Japan soak tofu in water for a short time and then slice it into standard size cubes for the market.

Composition

The composition of tofu varies depending on the bean variety used. A typical analysis of tofu (Smith, 1958) is 88% water, 6.0% protein, and 3.5% fat. Protein ranging from 6 to 8.4% has been reported.

Ways of serving

Although Japanese cookery generally has some similarity to Chinese cuisine, they have their own distinctive ingredients and ways to serve. The following are Japanese ways of serving tofu which show its versatility:

Without cooking:--One of the most popular ways to serve tofu in Japan is chilled and uncooked. A creative cook can serve chilled tofu in different ways every day of the year by choosing seasonal garnishes, subtly flavored dipping sauces and seasoned toppings. Cut tofu into small cubes and place in a shallow bowl. Sprinkle shoyu (soy sauce) or other favorite sauce over the tofu and top with one's choice of garnishes. Also, sauces and garnishes can be served in separate dishes so that individuals can help themselves to their own taste.

Chilled tofu is best to serve on a hot summer day. It is served with the meal or as a snack.

Boiling:--Fresh tofu adds protein, flavor, and variety to almost any kind of soup. It can be cut into small cubes, thin slices, or even crumbled and added to soup just a few minutes before cooking is finished. If cooked too long, tofu may lose some of its fine texture. Miso soups and other delicately flavored soups almost always contain tofu and are among the most popular at home or in restaurants. Miso, a flavoring agent, contains 16-18 percent salt. It is a paste made from soybean and cereals by a fermentation process. Of the three most popular ways of serving tofu--chilled, simmered, and in miso soup, only the latter is enjoyed throughout the year and at any of the day's three meals. Miso soup is an indispensable part of the traditional Japanese breakfast, together with rice and salt-pickled vegetables. In Japan, more tofu is

used in miso soup than in any other types of cookery. In addition to tofu, miso soup contains seasonal vegetables and garnishes. Bring soup stock or water to a boil. Add vegetables and continue to boil for a few minutes. Add tofu and simmer for 1 minute. Stir in miso creamed with a little of the hot broth and return just to a boil. Serve immediately.

Simmering:--In nabe (one-pot) cookery, which is similar to Chinese huo-kuo, the food is prepared right at the table in a large earthware casserole placed on top of a charcoal brazier. The nabe contains the entire meal and each individual cooks and serves himself from a wide range of seafoods, meats, vegetables, and tofu.

Broiling:--Firm pieces of tofu the size of small match boxes are pierced with bamboo skewers and lightly broiled. A simmered miso sauce or barbeque sauce is then spread on tofu surfaces. The tofu, broiled again until brown, is known as tofu dengaku. In Japan, tofu dengaku is usually prepared over a bed of red hot charcoal.

Deep-fat frying:--Deep-fried tofu is used in virtually every type of Japanese cuisine and is commercially available. At home, tofu tempura is prepared by deep-fat frying.

Japan is famous for its tempura cuisine. A typical tempura batter can be made by first mixing 1 egg yolk with 1 cup of ice-cold water. Add 1-1/4 to 1-1/2 cups of wheat flour and 1/2 teaspoon of salt, and lightly stir the flour in the egg mixture until all flour is moistened and large lumps disappear. Dip sliced tofu in the batter and fry in hot oil until both sides are brown. Serve hot with shoyu or other favorite sauces.

Tofu-egg pancakes:--Pancake batter is made with wheat flour, egg, and milk or water with the addition of tofu and chopped vegetables. Serve pancakes with Worcestershire sauce, shoyu, or miso sauce.

Kinugoshi Tofu

Kinugoshi tofu has a silky texture, soft and white; it is made from thick soybean milk. The curd and whey are not separated and pressed. Since whey is not removed in making kinugoshi tofu, it contains more of the nutrients originally present in the soybeans. This product is the same as tou fu nao in China.

Kinugoshi is easier and faster to prepare than regular tofu. The procedures for making tofu can be followed except only half as much solidifier is required. After the addition of the solidifier, let the curd stand for 20-30 minutes or until it is firm before serving. No pressing is required.

Kinugoshi is best served cool just as chilled tofu. Other main uses of kinugoshi are in miso soups, clear soups, and dishes served with various sauces.

Kinugoshi is now prepared by many Japanese shops in the United States from powdered soybean milk coagulated with lactone or calcium sulfate.

Processed Tofu Products

Many types of tofu products are made in Japan from regular tofu by frying and drying. These products are so popular that they are made commercially.

Aburage or age, nama-age and gammo

Aburage is fresh tofu fried in deep fat and is very popular in Japan. Fresh tofu used for frying usually contains less moisture than regular tofu. The tofu slabs are cut into small pieces and fried in two oil pots at different temperatures to give the best results. The first pot is at 100-110°C, where the tofu is held for 2-3 minutes. Then the tofu is removed to the second pot at 200-220°C, where it is held until golden brown (Smith, 1958). In deep fat frying, the water content is reduced and the oil content is increased, thus aburage is very rich in oil and protein.

A piece of aburage is about 20 cm. long, 8 or 10 cm. wide, and about 2 cm. thick (Shurtleff and Aoyagi, 1975). The outside has a skinlike formation; when the piece is cut in two in the middle, the cut end of each half is the opening of a pouch about 10-cm. long. One way of eating aburage is to fill these pouches with rice, vegetables, eggs, or meats.

Aburage can also be used in the place of tofu. Like tofu, aburage has a rather bland taste and is served with various sauces. Unlike tofu, aburage has more body and a chewy texture.

Besides regular aburage or age, there are nama-age (thick age) and gammo. Nama-age or thick age refers to age that is made from thick or whole cakes of fresh tofu. When a thick cake of tofu is deep-fried, it combines the softness of tofu with the crisp firmness and flavor acquired from deep-frying.

Gammo is a deep-fried tofu patty. Tofu, mixed with sesame seeds and finely slivered vegetables, is kneaded as if kneading bread. The mixture, after shaping into burger-sized patties or balls, is then fried in oil until golden brown. Grated yam or lightly beaten egg is frequently added to the mixture to serve as a binding agent. Carrots, onions, peas, mushrooms, and chopped nuts are the common vegetables used; sometimes they are slightly sauteed to increase their flavor.

Kori tofu (Dried-frozen tofu)

Frozen tofu has a spongy appearance and a meatlike chewy texture quite different from that of fresh tofu. Because of lack of freezing facilities, frozen tofu is usually made by exposing to cold weather; therefore, it is only consumed during the winter months. In order to create the spongy texture of frozen tofu and to prolong its shelf life, Japanese dry the frozen tofu.

The tofu slabs are cut into 1/2-inch thick slices, pressed in layers between boards to expel excess water, and then exposed to severe weather for 8 hours or until frozen solid. The sliced tofu is maintained in the frozen state from 1 to 3 weeks to develop the spongy texture. At the end of the freezing period, it is thawed in warm water and pressed to expel all the water. At this stage, it has a very spongy look and is ready for drying. The villagers use a shed heated with charcoal braziers to dry the tofu cakes. Today in Japan, based on these basic procedures, there are large capacity plants for making dried-frozen tofu. In modern plants, the cakes are given a final treatment with gaseous ammonia to increase water absorbing and swelling properties.

Dried-frozen tofu should be rehydrated by placing it in cold water before cooking. It is commonly used in nabe cookery, in soups, and in simmered and sauteed dishes. Properly dipped in tempura batter or eggs and deep-fried, it makes an excellent cutlet.

Yaki tofu (Grill tofu)

Regular fresh tofu is thoroughly pressed and then lightly broiled or toasted over open fire. Yaki tofu is delicious served hot with a favorite sauce.

Yuba (Protein-Lipid Film)

Yuba is the dried sheets of soybean protein containing emulsified oil and is equivalent to tou fu pi of China. It is made by boiling soyean milk and then removing and drying the film formed over the surface of the milk. Yuba is commonly made in three different states: fresh, half-dried, and dried. Dried yuba is very brittle and is rehydrated before cooking.

In Japan, yuba, especially fresh yuba, is prized for its use in delicate hors d'oeuvre. The variety of shape, textures, and flavors is unlimited. Fresh and warm yuba served with shoyu or other dipping sauce can be very delicious. Yuba is also cooked with many other dishes, and it requires only a few minutes of cooking time.

Soybean Milk

Although soybean milk is made at the first step of making tofu, it is not traditionally consumed by the Japanese.

Go (Ground Soybean Mash)

Most of the go made in tofu shops is used directly in the tofu-making process. Traditionally, go has also been used in home cooking. The most popular use for go is in thick miso soup, known as gojiru. Miso soup, as previously described, is a vegetable-tofu soup.

Daizu No Mayashi (Soybean Sprouts)

Daizu no mayashi is equivalent to Chinese Huany tou ya which has been discussed under China. In Japan, soybean sprouts are also used as vegetables, either parboiled for fresh salads, in soups, or in sauteed and simmered dishes.

Whole Soybeans

Like the Chinese, Japanese do not eat whole soybeans as much as processed soybean products.

Edamame (Fresh green soybeans)

Fresh green soybeans are a favorite vegetable in Japan just as they are in China. The green soybeans are simmered in the pot until tender, lightly salted, and served as a delicious hors d'oeuvre, often with sake or beer--or as a part of a meal. From mid-June until October, the green soybeans are served at the dining tables of restaurants and private homes throughout Japan. Cooked green soybeans (hitashi mame) are packaged commercially.

Whole dry soybeans

Dry soybeans are only occasionally cooked at home; most people buy them at the local delicatessen as a snack. There are two common ways of cooking dry soybeans: in one, soaked soybeans are boiled in water with shoyu in the other, soaked and drained soybeans are deep-fried in a sweetened batter and sold as a soy brittle.

Kinako

Kinako is a Japanese full-fat soybean flour product (Smith, 1958). Soybeans are roasted for 1/2 hour or longer until the characteristic toasted flavor is acquired. The beans are then cooled by spreading in the open, and are ground to a moderately fine flour. This process was originally carried out at farm homes as a small family industry; later, mechanization of the process was improved, and it became established as a commercial process. However, the production is still small as compared with all the other soybean foods.

The principal way of using kinako is to sprinkle it on rice or rice cake. The poor people of Japan are said to be the principal users of kinako.

Fermented Soybean Foods

Japanese consume great amounts of miso (fermented soybean-cereal paste) and shoyu (fermented soybean-cereal liquid) as flavoring agents. Although these fermentation processes, as well as other fermented soybean processes, have been carried out at small family-owned factories, they do require more sophisticated equipment, knowledge, and time. Miso, shoyu, and other fermented soybean foods, natto and hamanatto, are not reviewed in this report.

Production and Consumption

Japan is one of the major soybean consumers, 5.1 kg. per capita yearly (FAO, 1971); however, it produces less than 2 percent of the soybeans used as shown in Table 3. Japan uses more than 3,000,000 tons of soybeans yearly, 78 percent of that for oil, and 22 percent for food uses. The amount of whole soybeans used in making each one of the major soybean foods is given in Table 4. Of the 2,000,000 tons of defatted soybean meal produced yearly from oil extraction, 15 percent was used for traditional foods (Table 5). The yearly production of traditional soybean foods in Japan is shown in Table 6.

Table 3. Supply and Disposition of Soybeans in Japan from 1971 to 1974*

	Calendar Year			
	1971	1972	1973	1974
	1,000 metric tons			
Supply				
Beginning stocks	269	251	278	401
Domestic	53	55	53	60
Imports	3,212	3,396	3,635	3,244
Total supply	3,518	3,702	3,966	3,705
Disposition				
Crushing	2,481	2,636	2,739	2,729
Traditional foods	731	758	796	726
Feed	55	30	30	30
Total disposition	3,267	3,424	3,565	3,485
Ending stocks	251	278	401	220

*Source: Japan Ministry of Agriculture and Forestry (1976).

Table 4. Whole Soybeans Used in the Production of Traditional Foods in Japan from 1970-1974*

Type of Food	1970	1971	1972	1973	1974
			1,000 metric tons		
Miso	177	180	185	193	192
Shoyu	13	12	15	16	14
Tofu and others	508	521	537	550	539

*Source: Japan Ministry of Agriculture and Forestry (1976).

Table 5. Defatted Soybean Meal Used in the Production of Traditional Foods in Japan from 1970-1974*

Type of Food	1971	1972	1973	1974
	1,000 metric tons			
Miso	4	3	3	2
Shoyu	163	167	182	176
Tofu and others	130	130	130	NA

*Source: Japan Ministry of Agriculture and Forestry (1976).

Table 6. Production of Traditional Soybean Foods in Japan From 1970-1974*

Type of Food	1970	1971	1972	1973	1974
			1,000 metric tons		
Miso	552.2	560.7	578.8	590.0	587.2
Shoyu	1,334.1	1,354.6	1,416.6	1,529.8	1,455.8
Tofu and others	1,867.8	1,928.8	2,177.8	2,264.9	NA

*Source: Japan Ministry of Agriculture and Forestry (1976).

In Korea

Tubu (Soybean Curd)

Soybean curd is an important item in the Korean diet, even though it may not be used as extensively as in China and Japan. A large percent of soybeans grown in Korea is consumed as soybean curd.

Soybean curd has been made at home, especially by farm families, as well as in more than a thousand small shops. According to Smith (1949), small units, which on the average employ 5 men, can work up about 10 bushels of soybeans daily.

The method of preparing soybean curd is essentially the same as that used by the Chinese and Japanese. The curd is consumed as it is or in soup and in other dishes with fish, meat, and vegetables.

Processed Tubu Product

Tubu is the only traditional variety of Korean soybean curd. During the Japanese occupation, the Koreans developed a variety of deep-fried products which are very popular among the Japanese.

Soybean Sprouts

Soybean sprouts are much in demand as vegetables, especially during the winter months. They are sprouted and used much the same way as in China. In Korea, soybean sprouts are more popular than mung bean sprouts.

Whole Soybeans

Following are a few ways of eating whole soybeans in Korea:

Green soybeans

It is common practice in Korea to eat soybeans before they reach full maturity. The beans in the pods are simply boiled and eaten.

Parched or roasted beans

Soybeans are placed in a pan over a fire and heated slowly until the skin breaks and part of the bean is blackened. They are used as snacks, mostly during winter months.

Boiled soybeans

Soybeans are cooked with rice or with seasonings and served with regular meals.

Soybean Flour

Soybeans are first roasted and then ground into flour. The flour is extensively used as an ingredient in various food preparations.

Fermented Soybean Food (Kwon, 1972)

Soysauce and bean paste are commonly used in Korea as flavoring agents. Natto, a *Bacillus*-fermented soybean product, is also enjoyed by many Koreans.

Production and Consumption of Soybeans

Soybeans have been grown and consumed in Korea for centuries. In the Korean diet, rice is the most important and preferred grain, but

soybeans provide protein. A dietary survey of 1964-1967 conducted by Pak and Han (1969) showed that about 45 percent of the total food consumed in 1964 was rice, and they projected 49 percent by the year 1971. The yearly consumption of rice per capita increased from 129.8 kg. in 1964 to 146.3 kg. in 1967 and they projected 167.2 kg. by 1971.

Bean consumption was low compared to rice; but it increased at a greater rate, 5.8 kg. per capita in 1964 to 11.6 kg. in 1967, and projected 25.1 kg. for 1971. Furthermore, the consumption of beans per capita per year was greater in amount and in growth rate than that of either meat or fish.

Production and food uses of beans and the consumption of four soybean products (Pak and Han, 1969) are summarized in Table 7.

Table 7. Production and Food Use of Beans and Consumption of Some Soybean Products in Korea from 1964-1967

Year	Food Items	Production	Food Use	Amount Consumed	Per Capita
		1,000 Metric tons			kg./year
1964	Bean[a]	190	94		5.8
	Bean curd			223	
	Bean sprout			227	
	Bean sauce			57.4	
	Bean paste			22.9	
1965	Bean	203	104		6.9
	Bean curd			243	
	Bean sprouts			240	
	Bean sauce			61	
	Bean paste			24.3	
1966	Bean	195	117		10.2
	Bean curd			263	
	Bean sprouts			254	
	Bean sauce			64.8	
	Bean paste			25.8	
1967	Bean	236	134		11.6
	Bean curd			290	
	Bean sprouts			270	
	Bean sauce			69.7	
	Bean paste			27.7	
1971 (projected)		361	206		25.1

Table 7.--Footnotes

[a]Based on the production average of the 4 years surveyed, the beans consisted of 85% soybeans, 8.5% red beans, 1.6% green beans, 1.3% peanuts, and 3.4% other beans.

In Indonesia

Tahu or Tahoo (Soybean Curd)

The preparation of tahu or soybean curd in Indonesia is essentially the same as that carried out in China and Japan. There are two types of tahu available in Indonesia, regular and Chinese. In making regular tahu, ground bean mash is filtered after heating and the curd formation is achieved by the addition of acetic acid, lactic acid, or biyang (the overnight whey from a previous batch of tahu). The Chinese tahu makers, on the other hand, prefer to filter the ground bean mash before heating, and to coagulate the milk with calcium sulfate.

Tahu can be bought in the market every day, and it is consumed by everyone. Spicy dishes are prepared daily from tahu by almost every household (communication with I. Gandjar, Nutrition Research and Development Center, Bogor, Indonesia, 1976).

Bubuk Kedele (Soybean Powder)

Soybeans of the white variety are roasted until no beany flavor can be detected. They are ground into powder and mixed with spices such as garlic and chili. Bubuk kedele is kept in a jar and served only on special occasions with a rice product "longtong" (rice wrapped in banana leaves and boiled for 3-4 hours). Bubuk kedele is always homemade and is consumed by everyone (communication with I. Gandjar, Nutrition Research and Development Center, Bogor, Indonesia, 1976).

Tempe Kedele

Tempe is one of the most important soybean foods in Indonesia. It is a cake-like product made by fermenting soybeans with Rhizopus oligosporus (Hesseltine and Wang, 1972). The fermentation process is so simple that traditionally it has been carried out by almost every household. Tempe is not only easily made, but it also possesses the kind of texture and flavor that is universally acceptable and that cannot be provided by any other soybean product we know of.

Preparation

Material:--Soybeans and tempe starter. Any variety of soybeans is suitable for making tempe, and a piece of fresh-made tempe is often used as starter in Indonesia. Recently, a powder spore preparation of Rhizopus oligosporus (Wang et al., 1975) has been developed for tempeh fermentation.

Equipment:--Incubator and fermentation container. The optimal temperature for tempe fermentation is around 30-32°C. The Indonesians use no special incubator at home; they carry out the fermentation at air temperature. A simple incubator, however, can be constructed from a styrofoam picnic basket (30 X 40 X 30 cm.) by connecting a 7-1/2 watt light bulb as heat source. The basket can maintain a temperature between 30-31°C.

Traditionally, the Indonesians wrap the beans in banana leaves for fermentation. We have found that shallow (2-2.5 cm.) wooden, metal, or aluminum trays with pin-size perforated bottoms and covers or perforated plastic bags and tubes are quite satisfactory. Pin-size perforated containers would provide enough aeration to support adequate mold growth without excessive spore formation.

Procedure:--Making tempe in Indonesia is a household art. The procedures may vary in detail from one household to another, but the principal steps are as follows: Soybeans are soaked in tap water overnight until the hulls can be easily removed by hand. Some prefer to first boil the soybeans for a few minutes to loosen the hulls and then to soak the beans overnight. After dehulling, the beans are boiled with excess water for about 30 minutes, drained, and spread for surface drying. Small pieces of tempe from a previous fermentation, or ragi tempe (commercial tempe starter), are mixed with the soybeans. The inoculated beans are wrapped with banana leaves and allowed to ferment at room temperature from 24 to 48 hours depending on the air temperature. By this time, the beans are covered with white mycelium and bound together as a cake (Hesseltine _et al._, 1963).

Ways of serving

Tempe has a pleasant aroma and is usually consumed within a day. There are many attractive ways to serve tempe. The simplest and the most popular way to serve, however, is to cut into thin slices, dip into a salt solution, and fry in coconut oil. Sliced tempe can also be baked or added to soup as a vegetable.

Tempe is available in the big cities as well as in the villages. It is served daily as a side dish with rice and is also consumed as a snack. When fried very dry, tempe is even served at official receptions.

Tempe Gembus

Tempe gembus is made with the insoluble residue from making soybean milk and soybean curd. In other Oriental countries, the residue is used as animal feeds or is considered as waste.

In making tempe gembus (Gandjar, 1972), the residue is washed 2 to 3 times with cold water, pressed to remove excess water, steamed, and then inoculated with ragi tempe. The inoculated bean residue is placed in a wooden tray and covered with banana leaves to ferment for 24 hours. Tempe-like product is also made from "onggok" (waste of the tapioca plant.

Tempe gembus is soft as a sponge and easily sliced. When fried, tempe gembus has the soft texture and taste similar to that of french fried potatoes. By Indonesian standards, the taste of tempe gembus is inferior to that of tempe kedele, which has the nutty texture and aroma. Because tempe gembus is a low-cost food, it is consumed more by the low-income people. It is prepared and served just as tempe kedele and is very popular in Central and Eastern Java.

Oncom Tahu

Oncom tahu is another fermented product made from the residue of soybean curd, but Neurospora sitophila, a mold used in the fermented peanut product, ontjom, is used. Oncom tahu is similar to tempe gembus and is served in the same way. It is popular in Western Java.

Other Soybean Products

Soybean sprouts and green soybeans are used as vegetables; roasted and boiled soybeans are eaten as snacks.

In addition to tempe, fermented soybean products used in Indonesia are kecap (soysauce) and tauco (bean paste), which are used as flavoring agents.

Food Mixtures

A number of soybean-containing food mixtures developed or produced in Indonesia was reported by Winarno and Karyadi (1976). These foods, however, are not traditionally used in Indonesia.

Saridele

Soybean milk is not a traditional Indonesian soybean product, but a commercial product known as "saridele" was available. Saridele is a soybean milk enriched with peanuts and sesame seeds. The production of saridele, however, was discontinued after 1966 because of the irregular supply of soybeans and marketing problems.

Tempe-fish-rice (TFR)

This mixture consists of 30% tempe, 10% fish, 30% rice, 25% sugar, and 5% peanut oil.

Soy-rice baby food

This is a mixture of 1 part saridele to 4 parts of ground brown rice. The mixture is intended as a supplementary food for infants and children.

Soybean residue-fish-rice

In the preparation of soybean curd, a significant amount of protein is left in the residue. The soybean residue is dried and then blended with fish flour and rice flour. A blend consisting of 75% dried soybean residue, 15% fish flour, and 10% rice flour has 43% protein. The soybean residue-fish-rice blend can be made into cookies and crisps, added to vegetable soup, or roasted and eaten as is with rice.

Production and Consumption of Soybeans

Soybeans are an important crop in Indonesia. Indonesian exports account for 0.02 to 0.25 percent of the total world soybean export and between 0.2 to 6.7 percent of the total national production (Somaatmadja and Gubardja, 1976).

Data on soybean utilization in Indonesia have not been available. At present, a team of experts headed by Dr. F. G. Winarno, Dean of Agricultural Engineering and Product Technology, Bogor Agricultural University, Bogor, Indonesia, is conducting a nationwide soybean survey to obtain data on soybean production, total utilization, and food utilization. The survey is expected to be completed at the end of 1976.

From a phase-I progress report of the survey kindly provided by Dr. Winarno (1976), some preliminary data on production and food utilization of soybeans in Indonesia have been obtained and are listed in Tables 8-10.

The soybean production in Indonesia has been fairly constant from 1960-1974 (Table 8). Efforts are being made to increase the production. Per capita consumption (Table 9) varies greatly from one location to another which perhaps reflects the distribution of the crop and also the eating habits. Kecap (soysauce), tahu (soybean curd), and tempe are the most important soybean foods in Indonesia. The yearly production of these foods in central Java is shown in Table 10.

Table 8. Soybean Production in Indonesia from 1960-1974*

Year	Soybean Production (ton)
1960	442,862
1961	423,294
1962	396,839
1963	350,204
1964	391,693
1965	409,529
1966	416,769
1967	415,852
1968	419,932
1969	388,907
1970	497,883
1971	515,664
1972	518,229
1973	541,040
1974	550,000

*Source: Winarno, W. F. (1976).

Table 9. Consumption of Soybeans in Various Parts of Indonesia in 1970*

Province	Consumption kg./capita/year
Aceh	0.71
Sumatera, North	0.71
Sumatera, West	0.20
Sumatera, South	1.05
Jakarta dan Jawa	5.04
Kalimantan	0.16
Sulawesi, South, East, Central	0.68
Sulawesi, North	0.10
Bali	3.43
N.T.B.	14.14
Maluku dan Irja	0.90

*Source: Winarno, W. F. (1976).

Table 10. Production of Soybean Foods in Province of Central Java*

Year	Kecap	Tahu	Tempe
		tons	
1968	914,695	18,570	506
1969	1,865,560	19,610	602
1970	1,249,848	18,913	1,204
1971	1,289,000	14,500	44,200
1972	1,524,000	17,000	39,000

*Source: Winarno, W. F. (1976).

In Thailand

Soybeans are not a major agricultural product in Thailand, although they have been traditionally grown. After having been brought to Thailand, probably by migrating Chinese, soybeans became part of the Thai diet, and have been favored by people of Chinese origin. Tou hu (soybean curd) and soysauce are the most commonly used soybean products. However, green soybeans in the pods known as tou rae are also consumed.

Although soybeans have been consumed by the Thais for many generations, they cannot be considered as widely consumed. The Government of Thailand realized the seriousness of the protein deficiency problem in their country and has established a protein food development project at Kasetsart University, Bangkok, Thailand, with the cooperation of USAID to produce inexpensive protein foods for the nutritionally vulnerable groups of the population. A number of protein foods were developed; some of these products are soon to be manufactured by small-scale industries (Bhumiratana, 1970, 1976). Since they are not traditional soybean foods, these processes are not reviewed.

In the past, not many soybeans were grown in Thailand. But in recent years, production has been increasing as oil extraction expands and demand for soybeans on the foreign market increases. Data on soybean production (Table 11) for the past decade indicate that between 1972-1974 the area planted doubled, while total production more than tripled

from 72,000 tons to 252,400 tons. The utilization data are, however, scanty. The U.S. ICNND Nutrition Survey conducted in Thailand October-December 1960, by the Ministry of Health, Thailand, and the U.S. Interdepartmental Committee in Nutrition for National Defense, revealed that the average daily per capita consumption of soybeans by Thai civilians was 0.9 g. The FAO Food Balance Sheets 1964-1966 (1971) average showed an increase per capita of daily consumption to 1.5 g. or 0.6 kg. yearly. Average yearly soybean utilization as food during 1964-1966 was 17,000 tons, while average production was 41,000 tons.

Table 11. Area Planted to Soybeans and Total Soybean Production in Thailand*

Year	Area (rais)[a]	Production (metric tons)
1964	213,000	31,300
1965	117,000	19,100
1966	285,000	37,900
1967	399,000	52,800
1968	329,000	44,800
1969	299,000	48,200
1970	368,000	50,400
1971	359,000	54,300
1972	500,000	72,000
1973	893,000	152,300
1974	1,016,000	252,400

[a]6.25 rais = 1 hectare.

*Tongdee, A. (1976).

In the Philippines

The bean most commonly consumed in the Philippines is the mung bean known locally as "mongo." Soybean foods are eaten in the Philippines, but not to a great extent. In the Handbook of Philippine Agriculture (1931), the methods of preparing the following soybean foods were described: soybean sprouts, soybean coffee, soybean cake, soybean milk, tao-si (fermented soybeans), and toyo (soysauce). Other soybean foods consumed in China are also sold on the market in the Philippines (communication with S. Ling of Manila, the Philippines).

Soybean Sprouts

Soybean sprouts are prepared and can be cooked in the same way as mongo sprouts. The beans are thoroughly washed, soaked in water overnight, and then poured into a large earthen jar with a perforated bottom shielded with a bamboo or straw mat to prevent the beans from running out through the holes. The jar is covered with a straw mat to keep out the light. The beans are moistened at least two times during the day for 3 or 4 days, after which the sprouts will be 1- to 3-cm. long and ready for use. The sprouts may be allowed to grow up to the sixth day and still remain palatable. When allowed to grow up to the ninth day, the sprouts become fibrous. Soybean sprouts may be boiled and served as a hot vegetable or as cold salad. In both cases, they make excellent food.

Soybean Coffee

Dried soybean seeds when roasted and finely ground like dry coffee beans make an excellent substitute for coffee, and are said to have the color and flavor similar to coffee.

To prepare soybean coffee, clean the dried beans of dust and other foreign materials and roast them in a pot or frying pan as is done with coffee beans. Roasting usually requires from 15 to 20 minutes, depending upon the moisture content of the beans, the color of the roast desired (whether light, medium, or dark), and the skill of the operator. After being roasted, the beans are ground finely in a meat grinder. The "coffee" is then ready for boiling. The protein content of soybean coffee has not been reported; but it contains soluble soybean protein with certainty.

Soybean Cake

Soybean flour is prepared by cleaning and grinding the soybean in a meat grinder using the finest plate. If the flour is too coarse after one grinding, it may be run through the grinder a second time. Equal amounts of soybean and wheat flour are used to make soybean cake.

Soybean Milk

The beans are washed and soaked in water for about 6 hours with 3 changes of water, drained, and then ground in a meat grinder with small amounts of water added during grinding. Total amount of water required is about four times the volume of beans used. The ground beans are then strained through cheesecloth. The juice is boiled about an hour, after which it is again strained to remove the coarse particles which were not removed during the first straining. The resulting liquid is soybean milk.

Soybean milk is usually served with the addition of sugar.

Tou fu and Processed Tou fu Products

These products are perhaps the same as consumed in China. Gypsum is usually used in making tou fu from soybean milk. Tou fu is the most popular soybean food in the Philippines. Although no production figure is available, the largest tou fu shop in Manila used 1,200 pounds of soybeans daily.

Production and Consumption

Soybeans have long been grown in the Philippines; however, in spite of attempts to introduce several varieties, there are only a few that may be considered adapted to Philippine conditions. Based on the report by Coffing (1975), the Philippines produced 1,000 tons of soybeans in 1969, and production doubled in 1974. The Philippines imported soybeans

to meet their requirements. In 1973, 6,400 tons of soybeans were used for foods, and 5,500 tons for oil. The food use of soybeans, however, declined to 4,300 tons in 1974. No figure was reported for oil in 1974. The per capita consumption of soybeans was 0.1 kg. per year as reported by Darby et al. (1959), and 0.2 kg. per year during 1964-1966 based on the FAO food balance sheets 1964-1966 (1971). Data from an FAO (1971) report also indicated that the amount of soybeans used for food from 1964 to 1966 averaged 19,000 tons which is about 3 times the soybeans used for food in 1973 as reported by Coffing (1975).

In Burma

Burma is not one of the Asiatic countries known to use soybeans in their diet. Based on the report of a nutrition survey in 1961 conducted by the U.S. Interdepartmental Committee on Nutrition for National Defense (1963), the Burmese have been eating a significant amount of groundnuts and pulses. Pulses constitute about 19 percent of their daily protein intake.

FAO food balance sheets, 1964-1966 (1971) indicated that the average soybean production during the period was 6,000 metric tons, all of which was used for soybean oil. Over the years, the production of soybeans has been increased from 12,000 metric tons in 1969 to 15,000 metric tons in 1974 (Coffing, 1975). The use of soybeans as food is still a question.

In India

Dry legume seeds have a very important place in the traditional Indian cuisine. The commonest way of preparing legumes for consumption (Aykroyd and Doughty, 1964) is to boil them until soft, after which they are mashed, mixed with water, and boiled again to give a soup or gruel of uniform consistency. This may be eaten by itself with the addition of salt, a little oil or spices, and sometimes vegetables may be added and the mixture boiled again. Other methods of preparing legumes include grinding into flour, roasting, sprouting, and fermenting. They may be eaten as a main dish or as a side dish in a wide variety of forms. They also serve as the basis of soups, gruels, sauces, and savory snacks.

Soybeans, however, are not eaten by the Indians. The flavor and high oil content of soybeans make them unsuited to the Indian taste, if prepared in the same way as the other legumes. Thus, if soybeans are to be consumed in India, a different processing technology is needed.

A method for parching soybeans was received from C. V. Ramakrishnan of the University of Baroda, Baroda-2, India, but no information on consumption was given. The beans are soaked in water for about 5 minutes, wiped free of surface moisture, then put in a large frying pan containing preheated sand heated over an open fire, in a specially built oven, the temperature of the sand being about 250-280°C. The beans are rapidly stirred with an iron ladle for 4-5 minutes till they puff out, quickly transferred to a sieve, and the sand sieved off.

Strecter (1970), in his special report for the Rockefeller Foundation indicated that one of the most interesting new high-protein food products in India is a precooked weaning food called Bal-Amul. It has a soybean and milk base but is enriched by the addition of several vitamins and amino acids as well as calcium and iron. When mixed with warm water or fruit juice, it forms a smooth paste. Other soybean products tried in India include a precooked soup, soybean flour, and soybean milk.

At present, a small soybean milk plant is operating at G. B. Pant University of Agriculture and Technology, Pantnagar, U.P., India, with assistance from INTSOY. About 600-700 liters of soybean milk are sold daily on campus. Another pilot program has been planned which will produce 10,000 liters of milk for the surrounding village area.

In promoting the home utilization of soybeans in India, a soybean utilization team at U. P. Agricultural University, Pantnagar, consisting of 10 housewives from different states of the country tested and tried hundreds of Indian dishes using soybeans as a basic ingredient. As a result, a cookbook containing 221 recipes of low-cost, nutritious, attractive, and palatable dishes was compiled (Singh, 1970).

Soybean production, occupying an obscure position in India before 1964, has recently been brought into limelight as a new crop of great promise. In the past 10 years, several University of Illinois agronomists

have been associated with the soybean production research program in India. The results have been very encouraging (Leng, 1969; Hittle, 1974). Many on-farm demonstration plots were grown throughout the state of Madhya Pradesh; the yield varied from 15 to 57 bushels per acre. According to a recent preliminary report prepared by Coffing (1975) of Economic Research Service, USDA, soybean production in India increased from 11,000 tons in 1970 to 40,000 tons in 1974. Soybean utilization is still negligible.

In Malaysia

Soybean products are consumed in various forms by both humans and livestock in Malaysia. Tau foo (soybean curd), soybean milk, fu chok (yuba or tou fu pi), bean sprouts, and soysauce are the soybean foods recorded in the report of the Nutrition Survey of the Federation of Malaya, 1962, conducted by U.S. Interdepartmental Committee on Nutrition for National Defense (1964).

In making soybean milk, the soaked soybeans are wet-ground in a stone mill, and then the ground mass is filtered. The resulting milk may be sold as such, or with sugar and flavor added, bottled, and sterilized. The milk may be heated in a shallow pan and the resulting skim removed and dried to be sold as fu chok. Tau foo is produced by coagulating the milk with calcium sulfate. All these products are produced mainly in small 3- to 8-person establishments.

Soybeans have been grown in West Malaysia for 50 years. The soybean, which is grown among young rubber plants or as a sole crop in rotation with other annual crops, is planted primarily on small farms. The domestic demand, however, greatly exceeds the local supply (Abu Kassim b. Abu Baker, 1976).

The FAO food balance sheets, 1964-1966 (1971), showed that Malaysia imported a yearly average of 17,000 metric tons of soybeans, 16,000 metric tons for food use. The yearly soybean consumption per capita was 2.6 kg. which provided about 2.1 g of protein per day.

In Nepal

Although soybeans have been grown in Nepal for centuries, the amount is insignificant. The farmers have cultivated different varieties of soybeans in the terraces at altitudes ranging from 4,000 to 6,000 feet along with corn or millet in the same row, or as the borders of rice fields (Panday, 1975). Growing of soybeans or other edible legumes with other crops in an intercropping pattern is an old practice in Nepal. According to Panday (1975), the farmers only grow enough soybeans for their own use, due to lack of marketing facilities. The farmers use soybeans as animal feeds, especially for cows and buffalos during their lactating period.

There is no information on how popular soybeans are as food in Nepal; but Panday (1975) mentioned the methods of using soybeans in their diet as follows: (a) Roasted soybeans mixed with roasted corn are

eaten in the daily tiffin. (b) Roasted soybeans mixed with garlic, onion pieces, salt, and chili are served as a cocktail. (c) Sprouted soybeans mixed with other sprouted pulses are used in vegetable soups. (d) Green soybeans in the pods are eaten after steaming.

Recently, people in Nepal have started preparing milk and yogurt-like products from soybeans. Rice cooked in soybean milk with coconut pieces is becoming popular. They have also begun to use soybean flour in baby foods.

In Singapore

Since 80 percent of Singapore's population is Chinese, the use of soybeans as food in Singapore is not surprising. Based on communication with Bak (Soybean Oil Co., Singapore, 1976), tou fu (soybean curd) is the most common soybean food in Singapore. One can find its daily use at home as well as in the restaurants. Tou fu, however, is not very popular among the younger generation; they prefer bottled soybean milk as a cold drink.

Most of the other soybean foods consumed in China are also eaten in Singapore. Some of those soybean foods such as tou fu, tou fu kan, soybean milk, and soysauce are made with traditional methods, and others such as tou fu pi and chien chang are imported.

The production of soybeans in Singapore is practically nil. Information from the FAO food balance sheets, 1964-1966 (1971), indicated that 16,000 metric tons of soybeans yearly were imported during that period; 8,000 metric tons were used as food. Soybeans consumed per capita was 11.8 g. per day or 4.3 kg. per year.

In Sri Lanka

Information on production and utilization of soybeans in Sri Lanka was provided by C. Breckenridge, Food Technologist, Central Agricultural Research Institute, Grannoruwa, Peradeniya, Sri Lanka.

Soybeans are consumed by the people of Sri Lanka, but to a very small, almost negligible extent. When available, the cost of soybean products is relatively high there and they do not serve the role of everyone's protein. Simple soybean processes such as manufacture of flour and village preparation of soybean beverages have been proposed, but have not been implemented on a large scale. Laboratory studies are being carried out on these projects.

Because of the serious nutritional problem in Sri Lanka, the Sri Lanka Department of Agriculture has prepared a booklet on soybean recipes with the hope that the families will make more use of soybeans in their daily diet.

The booklet provides information on simple ways to prepare soybean flour and soybean drinks; and on various ways of using soybeans as

breakfast foods, sweet dishes, cakes, biscuits, and soybean stews; and on simply boiling and toasting soybeans. The booklet "Soybean Recipes" therefore, is included in the appendices (separate volume).

With the assistance of the INTSOY program, University of Illinois, Urbana, Illinois, soybeans are now grown in Sri Lanka on a relatively large scale. At present, 1,500 acres are used to plant soybeans with a yield of about 10 cwt per acre. The Department of Agriculture, Sri Lanka, is taking steps to increase the acreage to about 8,000 acres within the next 2 years.

Most of the soybeans produced are used in the U.S.-sponsored CARE project for blending with wheat flour and other cereal flour in the preparation of Triposhi--an infant weaning food. Present requirement for this project is 396 tons.

INTSOY is setting up a village demonstration plant in Sri Lanka for making soy beverage, baby foods, and meatlike products using the processes developed at the University of Illinois, Urbana, Illinois (Nelson *et al.*, 1971, 1976). According to Dr. A. I. Nelson of INTSOY, the plant is expected to be in operation by 1977.

In Vietnam

Soybeans are produced as well as consumed by the people of Vietnam. Dan fu and soybean sprouts are the most popular foods. Information on serving and preparing these foods is not available; probably the traditional Chinese methods in preparing these foods are used.

Based on the information from FAO food balance sheets, 1964-66 (1971), the average soybean production in Vietnam during these years was 13,000 metric tons, all of which was used for foods. The yearly per capita soybean consumption was between 0.3-0.4 kg.

In West Asia

In West Asia, where dry weather prevails, crop output suffers. Low rainfall affects the total agricultural production in countries like Jordan, Cyprus, Iraq, Israel, Lebanon, and others. However, in 1975 crop production increased substantially in Turkey and Iran, the two largest agricultural countries of West Asia. Wheat and cotton are the two big crops in that area (Economic Research Service, 1976b). Soybean planting is still in an experimental stage, even though it was introduced to Iran about 36 years ago. Potentially, soybean production is good. Under favorable conditions, Iran has produced 3 to 3.5 tons per ha of soybeans. In 1973, Iran produced 22,000 tons of soybeans; the production increased to 90,000 tons in 1975 (Lee, 1976). Turkey produced about 13,000 tons in 1974 (Coffing, 1975).

For expanding soybean cultivation in Iran, the problems are many. Lack of rainfall in needed time, fertilizer, proper inoculum, and problems in breeding, disease, agronomic operation, and planting technology are just a few. Despite all these problems, planting area in Iran is expected

to increase to about 120,000 ha 5 years from now. Currently, soybean production in Iran is in Khuzistan and northern littoral plain of the Caspian Sea area.

Other soybean growing areas in West Asia include Iraq, Mauritius, and Saudi Arabia, however, they are in observation plots and field trials.

Soybeans used in West Asia are mostly for oil production. Defatted soybean meals are usually for feed. Human consumption of soybean is limited to populations with Chinese origin. Methods for food preparation follow traditional Chinese ways.

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SOYBEAN FOOD USES AND PRODUCTION IN AFRICA

Soybeans are a comparatively new crop to Africa, consequently traditional foods based on them have not yet developed. Various studies have been conducted, however, to incorporate soybeans or soybean derivatives into traditional African diets. Meat protein and total protein consumption are low, and many diets are also lacking in calories with the result that protein-calorie malnutrition exists in some African nations. The use of whole soybeans in the diet would therefore be advantageous if the populations needing more proteins and calories could be so persuaded. Problems with cooking and palatability are often cited in attempts to use whole soybeans, although specific details concerning these difficulties are not given.

Examples of studies in different countries have been selected to illustrate the various approaches taken to incorporate soybeans into African diets. In addition, many African nations have been exposed to soybeans in the form of cereal-soy blends under the Food for Peace Program. Because of the large number of countries involved, they are not discussed individually. However, Table 3 in the Summary lists the nations receiving cereal-soy blends and quantities received during fiscal year 1974.

In Ethiopia

Work on the use of defatted soy flour in traditional recipes began about 1969 at the Ethiopian Nutrition Institute. Results were quite successful and work was later initiated with whole beans (Hiwot, 1975). Full-fat flour was prepared by one of the following ways:

1. Untreated soy flour. Beans were cleaned, split to dehull them, and ground into a flour.

2. Roasted soy flour. Clean beans were roasted, dehulled, and ground.

3. Blanched soy flour. Cleaned beans were blanched in boiling water for 10 minutes, air-dried, dehulled, and ground.

The full-fat flours were added to a number of traditional Ethiopian foods and evaluated by a trained test panel. Foods tested included the following:

Injera

A fermented pancake-like bread made from teff (Eragrostis tef), barley, sorghum, or corn is used by almost all highland Ethiopians. Soybean flours were blended with each of the cereals and converted into injera. Acceptable products were obtained with roasted soy flour, but the usable level varied with the cereal. Up to 20 percent soy flour could be blended with teff, whereas only 5 percent soy flour could be mixed with either sorghum or barley. However, soy flour could not be added to corn and converted into an acceptable injera.

Wots and Allichas

These are sauces served with injera and are usually made from meats, fish, legumes, eggs, and vegetables. Roasted soy flour was found to be a successful replacement for the legumes--pea flour, split peas, or split lentils.

Kitta

This unleavened bread used in the highlands and lowlands is made from wheat, barley, sorghum, or "ensete" (false banana). Blanched soy flour was successfully added at levels of 15 percent to wheat and barley and 10 percent to barley. Roasted flour was preferred for addition to ensete; up to 20 percent soy flour was added satisfactorily.

Dabbo

Dabbo is traditional leavened bread usually made from wheat. Up to 30 percent soy flour can be added to the wheat. Blanched soy flour gave excellent results, whereas use of roasted flour resulted in a darker, but still highly acceptable product.

Dabokolo

This is a snack food commonly known as "the travelers' food" because of its keeping quality. Either untreated or blanched soy flour worked acceptably up to 9 percent addition.

Porridge

A porridge made from barley, corn, or sorghum is frequently used in the lowlands and on special occasions in the highlands. Up to 20 percent blanched soy flour was added successfully to barley and corn, but sorghum-

soy blends did not give a satisfactory porridge.

The Ethiopian Nutrition Institute also produces two soy-containing food items used in famine relief activities. One is Faffa which is a weaning food and the other is SWF, an enriched wheat flour. Tonnages of the two products sold in 1973-1974 and projections for 1975 are as follows:

	Sales (tons)		
Product	1973	1974	1975
Faffa	700	800	1,000
SWF	1,000	2,000	2,600

In Kenya

Attempts are being made by the local government to develop soybeans as an oilseed crop in Kenya with financial assistance from international agencies (INTSOY, Rockefeller Foundation, and USAID). At present, soybeans are being imported, but major interest is in the oil for cooking. Poultry and livestock production is low; hence, there is no demand for protein feeds. The Ministry of Agriculture has attempted to develop simple recipes including soybeans for rural families, but acceptance is poor because of problems with long cooking times, flavor, and flatulence (Rackis and Akers, 1976).

In Morocco

Cereal-soy blends have been used extensively in Morrocco. In fiscal year 1974, 14.7 million lb of cereal-soy blends were shipped to Morocco (Table 3, Summary). It is predicted that shipments of soy-fortified rolled oats and soy-fortified bread flour will increase in fiscal year 1976. Wheat-soy blend is used in the school lunch program and apparently is accepted as a food item. However, wheat-soy blend is not sold in the commercial retail markets (Rackis and Akers, 1976).

Mmbaga (1975) has reported briefly that soy flour is being utilized in making porridge using 1 part soy flour to 3 parts maize flour. Breads containing 10 percent soy flour and 90 percent wheat flour are common, particularly in the Morogoro region. School feeding programs use porridge and soy milk extensively, and acceptability is reported to be high.

In Nigeria

Soybeans are an established crop in several areas of the country, but they have never become a popular foodstuff. Ashaye et al. (1975) list the following problems encountered in trying to incorporate soybeans into the Nigerian diet: (a) poor soaking and cooking qualities; (b) lack of palatability; and (c) undesirable changes in color during cooking. Most of the soybeans produced in Nigeria are exported as a cash crop to Europe and a small amount is fed to animals. Kay (1974) has worked

extensively to develop simple ways of incorporating soybeans into the Nigerian diet. These include the use of whole soybeans and a paste obtained by grinding beans after soaking them in water.

Whole Soybeans

Whole beans are used in baked (roasted?) form and in stewed dishes. The baked form is sometimes ground and mixed with sugar to taste. For stewing, the beans are boiled in water containing a small amount of baking powder.

Soybean Paste

This is the starting material for a variety of food uses. The paste is made by soaking the beans 8-10 hours with about 2 volumes of water, crushing with a grinding stone or corn grinder, and then grinding to a creamy paste in a mortar.

Two direct uses of soybean paste have been described. In one, the paste is mixed with cereal (guinea corn meal, maize, or wheat flour), minced onion, salt and pepper, and then deep-fat fried to yield Kosei (akara ball). In the second direct use, the soybean paste is mixed with wheat flour, baking powder, beaten egg, and sugar. The resulting batter is then dropped into hot peanut oil and deep fried to give panke (puff-puff).

Less direct use of soybean paste consists of preparation of soybean milk in essentially the traditional Oriental way. The paste is mixed with 2-3 parts of cold water. The resulting bean slurry is filtered and the filtrate boiled 10-20 minutes. Because of generation of grassy-beany flavors when the beans are ground with water, the Cornell University method has also been considered. This process consists of grinding the beans with hot water (80°C or higher), filtering, and then simmering the filtrate for 10-20 minutes. Soy milk can be used to prepare protein-enriched pap (soy milk mixed with guinea corn meal and sugar and reboiled) and protein-enriched fu-fu (gari mixed with hot soy milk instead of hot water). The residue remaining after preparation of soy milk by the Cornell process still contains ∿30 percent protein and can be incorporated into alele (moin-moin). Alele is made by mixing soy milk residue with akamu (guinea corn meal), corn or wheat flour, or beaten egg, minced onion, salt and pepper, wrapping the mixture in leaves, and then steaming for 20 minutes or longer.

Soy milk has also been used to make tofu-like products by adding calcium or magnesium sulfate or an acidic fruit juice (such as lemon or pineapple) to coagulate the protein-lipid complex.

Corn-Soy Mixtures (Soy-Ogi)

Corn (maize) is the principal cereal cultivated in Southern Nigeria and is an important part of the human diet. Corn is eaten as whole grain in roasted or boiled form or may be consumed in the form of ogi, which is a partially fermented starchy product obtained by a wet-milling process. Corn is soaked in water for 3 days and allowed to ferment. During this time, an extensive microbial population develops. The steeped kernels are then ground in a corn mill. The resulting slurry is sieved to remove the hull. Next, the sieved starch suspension is allowed to settle to yield the product called ogi. For consumption as a food, the water is decanted and the wet cake is added to boiling water to form a gruel known as "pap" which is popularly consumed for breakfast (Oke, 1967).

Because ogi is primarily starch and its protein has a low biological value, it has been mixed with full-fat soy flour to improved its overall nutritive quality. Akinrele and Edwards (1971) have assessed the nutritive value of a 70:30 mixture of ogi and full-fat soy flour called Soy-Ogi. They found it to have a protein efficiency ratio equal to that of a commercial milk-based infant food. Soy-Ogi is well tolerated by weaning children and clinical responses with it were as good as those obtained with the milk-based product.

Soy-Ogi is currently produced on a pilot-plant scale in which corn is soaked, wet-milled, sieved, and blended with cooked, full-fat soy flour. After mixing, the slurry is spray dried. Addition of vitamins and flavors yields an infant food of excellent acceptability. Commercial production is envisaged in the near future (Onyekwere, 1976).

In Tanzania

Soybeans are grown on a limited scale in Tanzania, but there is interest in expanding growth of this legume and in its use for human consumption. In 1973, workers described a study in which soybeans were converted into full-fat flour in three Tanzanian villages using the simple process developed at the Northern Regional Research Center (Holm et al., 1973). The resulting flours were analyzed for protein content, amino acid composition, and trypsin inhibitor content. Large variations in trypsin inhibitor content were observed, but a composite of three flours gave a protein efficiency ratio of 2.2 (corrected to 2.5 for a reference casein) which is typical of an adequately processed soy flour.

In Uganda

In the mid 1960's, Africa Basic Foods Inc. was established in Kampala by the Uganda government to develop low-cost, high-protein foods to help solve the problem of protein-calorie malnutrition. Pilot production of full-fat soy flour, soy milk, and soy cheese (similar to tofu) was

begun, and marketing was directed toward the poorest segment of the population most in need of a better diet. The growth of soybeans was also actively promoted. The Ministry of Agriculture initiated field trials with different soybean varieties in 1965, and the University of Makerere started variety trials in 1966 (Harrison, 1969).

Production

Soybeans are still a minor crop in Africa, and production is so small that listings of commodities often do not include this crop. Because of the small crop, production figures from different sources frequently do not agree. Areas harvested and production estimates for 1976 for six African nations are as follows:

Country	Area harvested 1,000 hectares	Production 1,000 metric tons
Ethiopia	10	6
Nigeria	--	1
South Africa	12	19
Tanzania	5	4
Uganda	5	3
Zaire	2	1

Source: United States Department of Agriculture (1976).

South Africa is the major producer and accounts for 56% of the total soybean crop in Africa. Nigeria is an example of a country for which conflicting production figures can be found. The Food and Agriculture Organization of the United Nations (1975) estimates the 1974 production as 65,000 metric tons as compared to 1,000 metric tons reported above for 1976 (the Foreign Agriculture Service source also reports only 1,000 metric tons for 1974 production).

Prospects for increasing soybean production in Africa are unclear at present. Although experimental plantings are underway in a number of countries, a variety of problems need to be resolved before significant increases in production are likely to occur. These problems include: (a) climatic conditions; (b) soil conditions; (c) lack of proven varieties adapted to different environments; (d) plant and insect pests; (e) lack of harvesting equipment; (f) lack of suitable innoculum to ensure effective nodulation; and (g) lack of storage and processing facilities to handle the crop.

Many of the obstacles to increased soybean production do not appear insurmountable because similar difficulties have been overcome in other countries. Perhaps one of the most difficult problems will be to give the farmers sufficient incentives to grow soybeans in place of some of their present crops. It is likely that production will increase slowly as problems are solved and suitable markets are found for this oilseed.

SOYBEAN FOOD USES AND PRODUCTION IN EUROPE

Soybeans are grown in only a few countries of Europe. Area and production estimates for Europe and USSR for 1976 are as follows:

Country	Area 1,000 hectares	Production 1,000 metric tons
France	4	10
Spain	22	35
Bulgaria	58	100
Hungary	40	55
Romania	200	250
Yugoslavia	32	50
USSR	850	500

Source: United States Department of Agriculture (1976).

The major producer is USSR, followed by Romania and Bulgaria. These three countries account for 85% of the total crop grown in this area.

To the best of our knowledge, there are no simple home or village type uses of soybean protein in foods. The soybeans are processed into oil and meal and the latter is used primarily as an animal feed.

Food uses of soy protein in Europe are typical of those in developed countries such as the United States. Two recent publications summarize food applications in Europe (American Soybean Association, 1974, 1975).

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SOYBEAN FOOD USES AND PRODUCTION IN LATIN AMERICA

In Argentina

In 1974, Argentina had a soybean production of 496,000 metric tons (FAO Production Yearbook, 1975), but soybeans are not utilized as foods at the home or village level in this country. According to Predicasts, Inc., Report No. 108, " Argentina had the highest per capita protein consumption in Latin America in 1972 as well as the highest meat consumption. Synthetic meats and extenders are expected to comprise only 5 percent of total meat consumption in 1985 because of the abundance of natural meats available to the consumer. Because of this, protein enrichment of the average diet is not really necessary in Argentina. In addition, consumer resistance to synthetic meats is expected to have a more adverse affect than in other Latin American countries. Consumption of soy-derived meats is projected at 50,000 tons in 1980 and 150,000 tons in 1985; highest consumption will in all likelihood be in scattered very low income urban areas.

Soy flour, for the same reasons cited for synthetic meat, is projected to constitute a very small percent of total protein consumption, in all likelihood less than 0.5 percent in 1985. Wheat flour is providing (and will continue to provide) over 25 percent of Argentina protein consumption. Very little need is foreseen for protein-rich flours to augment a diet centered around meat and high-quality wheat flours (corn is not even utilized to any appreciable degree as a human food). Consequently, all engineered soy protein foods will comprise less than 3 percent of overall Argentina protein consumption in 1985, up slightly over an initial penetration of about 1 percent by 1980."

In Bolivia

In 1974, Bolivia had a soybean production of 2,000 metric tons, but soybeans are not grown or utilized as foods at the home or village level in this country (FAO Production Yearbook, 1975).

Quoting Predicasts, Inc., Report No. 108, p. 34, "All other Latin American countries except for Argentina, Brazil, Mexico, and Uruguay, had protein-deficient diets during 1961-1972, derived from low-quality grains. Per capita protein consumption did not appreciably rise between 1961 and 1972 due to inordinately high population growth (about 3% per year) which outpaced supply of many high-protein foods.

"Natural meat consumption will continue to increase at about the historical rate, 3% per year, to about 4.2 million tons in 1985, because of programs in Ecuador, Chile, and Uruguay to stimulate meat production more economically on massive corporate ranches.

"Soy flour use will exceed 200,000 tons by 1985, capturing about the same share of the total protein mixture as meat substitutes, about 2.5 to 2.6 percent. Use of soy flour bakery additives and substitutes will not be as widespread in most of these countries as will be evident in Brazil and Mexico, because of less familiarity with soy products and their taste. Public dietary improvement projects and retail prepared food distribution channels are less evident than in Mexico or Brazil. Also, priority will inevitably be placed upon domestic soybean use as feed (rather than human food) to aid in bolstering output for already established meat and poultry export programs in Ecuador, Columbia, Chile, and Peru."

According to Dr. Ben Buchanan's trip report, April 1, 1976, covering his initial tour of Latin American countries, there has been considerable migration from the rural areas of Bolivia to the urban outskirts, with no jobs for the migrants. This has compounded the malnutrition problem. He continues to say "the Ministry of Health has started Mothers Clubs supplying foods for the family and educational materials for use by groups as they meet. Mothers who are somewhat more educated and tend to be leaders are chosen to continue the program after the first meeting with a representative from the Ministry. There is some question as to the success of this program. Also, the Ministry of Health supports a rural school lunch program which is beneficial. The breakfast program in urban centers, however, is being phased out."

In Brazil

The production of soybeans in Brazil for the year 1974 was 7.5 million metric tons (FAO Production Yearbook, 1975) and estimated to increase to 11.6 million metric tons for 1976 (World Agricultural Pruduction & Trade Statistical Report, FAS, January 1974). Soybeans have not been utilized at the home or village level in this country.

In 1967, at the request of the Brazilian Ministry of Health, Mr. G. C. Mustakas (1967), NRRC Chemical Engineer, demonstrated his village process (full-fat soy flour) in Brazil for fortifying milks and other weaning foods with soy protein. Brazilian scientists were interested

in the process and consequently, UNICEF, acting in agreement with ABCAR/UNICEF/FAO/OMS, made available six sets of machines for experimental study in Brazil. The machinery was sent to (1) Ministry of Health at Rio de Janeiro, (2) Santa Maria Federal University at Rio de Janeiro, (3) University of Ceara at Fortaleza, (4) Federal University of Pernambuco at Recife, (5) Federal University of Paraiba at Campina Grande, and (6) Ecole Superieure at Piracicaba, State of San Paulo.

So far, little information has been received on the results with these machines, since no national organization was responsible for coordinating the experimental results. Professor Chavez and his group at the University of Pernambuco not only processed soya, which is not produced in Northeast Brazil, but also other edible beans like the feijao macassa bean. His results were encouraging; consequently, he stated that he would like to make the process available to the rural areas of the south. In 1969, one report stated that by 1973, several international organizations envisioned the distribution of 100 machines to rural areas of Brazil. No further progress report on this statement has been received.

According to Predicasts, Inc., Report No. 108, pp. 31-32, "Per capita Brazilian protein consumption was below the average world minimum of 0.070 kg. per capita per day in 1972, and qualitatively the protein mix was characterized by large quantities of food having poorly balanced and incomplete amino acid components (such as fruits, vegetables, and low protein grains). Total meat consumption grew 3.5 percent per year.

"Total meat and substitute consumption will increase 4.5 percent per year to over 4.2 million tons in 1985 due to rapid market penetration by soy-derived substitutes. Consumer resistance to the new synthetic meats is expected to be less of a hindrance than in Argentina; Brazil is a major soybean producer and the vast majority of its people are acquainted with and accustomed to the taste of this and other bean products in their diet. In fact, Brazilian culinary tradition includes wide use of related vegetables and fruits as integral parts of meat, poultry, and egg dishes.

"Soy flour is already a small part of the Brazilian protein mix, especially in depressed urban areas. Consumption will grow over 14 percent yearly between 1972 and 1980 and as fast as 25 percent annually thereafter to about 180,000 tons in 1985. By 1985, flour is projected to make up over 2.5 percent of total protein consumption."

In Chile

Chile is currently producing only about 250 metric tons of soybeans per annum (P. Crowley, J. C. Edozien, AID Trip Report, October-November, 1976), but soybeans are not utilized as foods at the home or village level in this country.

According to Dr. Buchanan's trip report (April 1, 1976) on Latin America, "It is estimated there are 50,000 severely malnourished children in Chile, mostly in localized areas where a test pilot project could be

tried. The Chilean government plans to use a food stamp program to try to reach these cases. Education is badly needed. Apparently the Allende administration encouraged the movement of thousands of poor and not so poor from the rural sectors, where they could, and did, subsist on their small farm plots, to urban areas, through his promised giveaway food program which failed to materialize--thus aggravating an already difficult situation of unemployment and welfare dependence."

According to Predicasts, Inc., Report No. 108, p. 34, "natural meat consumption will continue to increase at about the historical rate, 3 percent per year because of programs in Ecuador, Chile, and Uruguay to stimulate meat production more economically on massive corporate ranches. Total meat and substitute consumption will increase over 4 percent annually due to penetration of soy-derived substitute products which are expected to be about 13 percent of meat consumption by 1985..."Soy flour use will exceed 200,000 tons by 1985 capturing about the same share of the total protein mixture as meat substitutes, about 2.5 to 2.6 percent. Use of soy flour bakery additives and substitutes will not be as widespread in most of these countries as will be evident in Brazil and Mexico, because of less familiarity with soy products and their taste. Public dietary improvement projects and retail-prepared food distribution channels are less evident than in Mexico or Brazil. Also, priority will inevitably be placed upon domestic soybean use as feed (rather than human food) to aid in bolstering output for already established meat and poultry export programs in Ecuador, Columbia, Chile, and Peru."

In Colombia

Our findings show that no soybeans are utilized in foods in this country. Although considerable effort is being made to introduce soy foods here, these efforts are all in the experimental stages.

Colombia has a population of 24 million with a per capita income of $370, of which 37 percent is spent for food. In 1974, 156,000 metric tons of soybeans (FAO Production Yearbook, 1975) were grown in the country which exports coffee, petroleum, cotton, sugar, and bananas.

Five oilseed processors are in Colombia. Grasas S.A. has a 220 ton/day solvent extraction plant now processing soybeans and other oilseeds. They are getting an extruder from the U.S. and will start making textured soy protein within a year.

Predicasts, Inc., Report No. 108, has reported on per capita protein consumption and natural meat consumption, pp. 34-35. Soy flour use in Colombia as human food is considered to be small and highest priority will be for domestic soybean use to go to feed rather than human food (see paragraphs 1, 2, and 3 under "Bolivia") to bolster output for already established meat and poultry export programs.

A soy milk-like beverage powder has been developed by the Instituto de Investigaciones Technologicas according to researchers Drs. D. D. Delgado and Norton Young Lopez. This yellow-white powder contains 45 percent protein and 25 percent fat and can be dispersed in water to yield a drink with dairy-like flavor.

Native Colombia foods that might be formulated with soy proteins are empinada (puffed pastry), ajiaco (potato soup), arepas (baked, small round breads with cornmeal), noodle soups, puchers (soup with pork, beef, or sausage and vegetables such as plantain, casava, and corn), cullada (atole), and cereal gruels made with oatmeal, wheat, or corn.

El Instituto de Investigaciones Tecnologicas is responsible for most of the product development activities of the various National Government Agencies and appears to be the focal point of food product development for the malnourished in Colombia.

In Ecuador

In 1974, Ecuador had a soybean production of 1,000 metric tons (FAO Production Yearbook, 1975). Soybean production is being increased and new programs for food products from soy are underway. Quoting from Dr. Ben Buchanan's trip report dated April 1, 1976 (Grant No. AID/ta-G-1238), "In Quito, one institute has a program on the development of flours for making bread, pasta products, and crackers. There is an intensive effort in the fortification of wheat with soy, potato, and rice flours. They have been successful in replacing from 30 to 50 percent of the wheat flour with other flours. A process is being developed to make soy milk. Another for full-fat soy flour. It is hoped the increased availability of soy products will help relieve protein malnutrition conditions in Ecuador."

According to information obtained from Meals for Millions workers who were doing field work in Ecuador (Mark M. Sterner, Executive Director, Meals for Millions Foundation, private communication, 1976) a group of Ecuadorians living in the Sierras have adopted home-grown soybeans as a daily food prepared in their home. The food product called "Matchaka" consists of whole soybeans that are toasted then ground in hand coffee mills. Coarse sugar is added and the mixture eaten as a dry snack. Previously, corn was used to prepare this product.

Predicasts, Inc., Report No. 108, has reported on per capita protein consumption and natural meat consumption, pp. 34-35. Soy flour use in Ecuador as human food is small and highest priority will be for domestic soybean use to go to feed rather than human food (see paragraphs 1, 2, and 3, under "Bolivia") to bolster output for already established meat and poultry export programs.

<u>In Guyana</u>

Soybeans are not grown or utilized as foods at the home or village level in this country. With a population of only 750,000, the government has a highly restrictive import policy against many food products. The main exports are sugar, bauxite, and rice with an average per capita income of $300 per year (Mustakas, G. C., Trip Report, March-April 1975). Some 60 acres of soybeans have been grown experimentally and plans are underway for the government to build a soybean and rice bran crushing plant.

In Paraguay

Last year (1974), Paraguay had a soybean production of 170,000 metric tons (FAO Production Yearbook, 1975), but no utilization of soybeans at the home or village level.

According to Dr. Ben Buchanan's trip report dated April 1, 1976 (Grant No. AID/ta-G-1238), "Paraguay is the only Latin American country in which we found a migration trend from urban to rural areas. It is estimated that an additional million acres of land have been converted to productive agricultural property in the past five years. Paraguay is a beef exporting country but the European market has deteriorated as a result of the EEC policies, so that now they are seeking other outlets. As a result, also, beef prices in the market place are very low, good, lean beef being the equivalent of less than a dollar per pound. Pasta products are now being made with 20 percent of soy flour and 80 percent wheat flour to conserve the limited wheat production. Malnutrition is not a severe problem in Paraguay but there are pockets of goiter in the Northwest rural areas and some vitamin A and calorie/protein malnutrition in some of the rural and suburban sectors."

Quoting Predicasts, Inc., Report No. 108, p. 34, "All other Latin American countries except for Argentina, Brazil, Mexico, and Uruguay had protein deficient diets during 1961-1972, derived from low-quality

grains. Per capita protein consumption did not appreciably rise between 1961 and 1972 due to inordinately high population growth (about 3 percent per year) which outpaced supply of many high-protein foods. Natural meat consumption will continue to increase at about the historical rate, 3 percent per year. Use of soy flour bakers additives and substitutes will not be as widespread in most of these countries (including Paraguay) as will be evident in Brazil and Mexico, because of less familiarity with soy products and their tastes."

In Peru

In 1974, Peru had a soybean production of 1,000 metric tons (FAO Production Yearbook, 1975), but no utilization of soybeans at the home or village level. According to information from Professor A. I. Nelson of the University of Illinois, there is an AID-INTSOY program in Peru relating to soybeans and soy food production. In discussing this program while visiting our laboratory, Professor Nelson related to us the specific and high interest at the Food Institute at La Molina (Lima, Peru) on our soy food-related research, particularly our extrusion cooking process for producing full-fat soy flours.

Predicasts, Inc., Report No. 108 (pages 34 and 35), has reported on per capita protein and natural meat consumption. Use of soy flour in Peru as human food is considered to be small and highest priority will be for domestic soybean use to go to feed rather than human food. (See paragraphs 1, 2, and 3 under "Bolivia") to bolster output for already established meat and poultry export programs.

In Uruguay

In 1974, Uruguay had a soybean production of 6,000 metric tons (FAO Production Yearbook, 1975), but soybeans are not utilized as foods at the home or village level in this country.

According to Predicasts, Inc., Report No. 108, p. 34, the country of Uruguay had no protein deficiencies in the diets of its people during the period of 1961-1972. According to Dr. Buchanan's trip report to Latin America (April 1976), p. 16, "It is quite obvious Uruguay is progressing well in the utilization of applicable technology not only from the developed countries but also from the other more developed Latin American countries, particularly Brazil. We were told malnutrition is not a severe burden, but they do want to improve nutrition among preschool children and pregnant and lactating women, therefore, they were much interested in our program and want to help in any way possible. The Ministry of Commerce and Industry working with the University is beginning to make progress in adapting and transferring applicable technology to industry."

According to Predicasts, Inc., Report No. 108, p. 34, "Natural meat consumption will continue to increase at about the historical rate, 3 percent per year because of programs in Ecuador, Chile, and Uruguay to stimulate meat production more economically on massive corporate ranches.

Total meat and substitute consumption will increase over 4 percent annually due to penetration of soy-derived substitute textured products which are expected to be about 13 percent of meat consumption by 1985. This is slightly lower than the projected penetration in Mexico and Brazil because of the inclusion of Uruguay where dietary tradition is centered around a wide variety of natural meats and other relatively plentiful high-protein foods."

In Venezuela

With a population of 12 million people, soybeans were still not being produced by 1975 even though about 55,000 metric tons (1.5 million bushels) of soybeans and 83,000 metric tons of soybean meal were imported in 1974 (Mustakas, G. C., Trip Report, March-April 1975). No soybeans are utilized as foods at the home or village level in this country.

Venezuela has only a few small oilseed processors crushing imported soybeans into oil and meal. One company (Proteinal C.A.) makes edible soy flours.

Native foods consist of the pabellon plate (stringy beef, rice, sauce, potatoes, and vegetables) and arepas (little round corn breads fried and stuffed with ground meat and highly seasoned onions, chili sauce, peppers, and garlic). Tamales (Hiralloca) are cooked in banana leaves and stuffed with ground meat and cornmeal. As a food demonstration during my trip there in March-April 1975, fried arepas were prepared

with textured soybeans and local green chili and tomato sauces. Acceptance was excellent as noted from the meeting attendance which included representatives of government, industry, and academic institutions (Mustakas, G. C., Trip Report, March-April 1975).

In Mexico

Mexico has a population of over 55 million and some 37 percent of the per capita income of $700 is spent on food. A number of government programs have been underway since 1970 to introduce soybeans in the diets of both the urban and rural population. Numerous nutritional studies in Mexico have shown that 31 percent of children in rural areas and 16 percent in urban areas are in a state of second and third degree malnutrition and require medical attention (Anon., 1975a). In Mexico, every year, ca. 2 million children are born, of which 300,000 die before they reach the age of five due to problems related to the malnutrition-illness cycle (Anon., 1975b).

According to Predicasts, Inc., "Mexican protein consumption has been highly deficient. Not only has it been below the minimum required level in quantity, but quality of the protein mix has been poor due to insufficient balance between low grade corn-derived proteins (47-54 percent of consumption) and meat-derived proteins. Per capita meat consumption has been among the lowest in Latin America due to insufficient local production, much of which was exported at higher prices than consumer incomes could afford. Total meat consumption increased only 1.3 percent annually between 1961 and 1972."

Prior to 1969, soybeans were planted only in the states of Sonora and Sinaloa along the eastern coast of the Gulf of California. Soybeans are now grown in most of the states across the north of the country and in Jalisco, a west-central state. Production has been increasing over 6 percent a year with last year's production amounting to 500,000 tons. Varieties which can be grown in the more tropical states are also available, making possible an even greater increase (A. J. Pontecorvo, LIFE Newsletter, May 1976).

In the early seventies, when the President of Mexico was starting his new term of office, he created a new National Council of Science and Technology (CONACYT) at the cabinet minister level. As part of this program, he announced publicly that he considered soybeans as a natural part of the diet for the Mexican people and he expected through the new program to promote soy proteins in the national food diets.

During the years since that time, both representatives of the Government and Mexican Industry have cooperated in such a national program. Market development activities shared by the American Soybean Association, (Harrison, 1972) Mexican Government, and private firms have helped raise the production and demand for soy protein products from 2 tons daily in 1971 to over 40 tons daily at the present time (Tello, F., 1975).

According to Predicasts, Inc., "Soy flour will comprise an even larger percentage of Mexican protein consumption in 1980 and 1985 than soy-derived meats, 3.5 percent of the total protein mix in 1985 compared with 2.6 percent for meat substitutes. This will be a result of the composition of the traditional diet which is centered around grain flour and bean mixtures as staples, a custom that will facilitate easy acceptance of soy flour (especially as a "hidden additive" to popular low-protein corn flours). Hence, Mexico will have, in all likelihood, the highest protein mix penetration by soy flour (3.5 percent in 1985, or over 140,000 tons of flour) of all Latin American countries. As in the case of synthetic meats, Mexico's proximity to large American soybean and soy flour production centers (in Texas and throughout the Southern states) will stimulate availability in Mexican markets and aid in pushing total per capita protein consumption to the average minimum requirement of 0.070 kilograms per day by 1985."

New Village Processes for Utilizing Soybeans in Human Diets

Most of the soy products on the Mexican market were not available to the lower classes even at their low cost.

During 1974-1975, 30 sets of village process equipment were delivered to Mexico through the auspices of the United Nations Childrens Fund.

One of these units was delivered to the National University of Mexico where workers there studied the process and its application towards traditional end food products in Mexico. As a result, workers

R. Berra and Aldo Pontecorvo-Valhuerdi (1975), published a slight modification to the original NRRC process as a means of guiding the process more directly toward traditional food products such as milk, atole, and pasta. Figure 1 is a flowchart showing modifications in the USDA village process (Mustakas *et al.*, 1967).

According to the authors, the heavy liquid obtained after boiling could be used as "atole" or a soup containing vegetables, such as potatoes, carrots, and onions, indigenous to the region. A beverage was an alternate product and could be made even more acceptable to the people by boiling it with aromatic products such as cinnamon, vanilla, and cacao. Another alternate product referred to as a "pasta" could be used as human or animal food. Humans could eat it as cereal combined with the fruits of the region. It also could be dried in the traditional ovens to make cookies or ground again to make a powder to be combined with corn or wheat. In this way, it could be preserved a long time.

The yield and protein analysis of the basic products from 1 kg. soybean, adding about 9 liters water in the boiling process are as follows:

Product	Yield	Protein (%)
Milk	6-7 liter	4
"Atole"	2-3 liter	8
Pasta	2-3 kg.	18

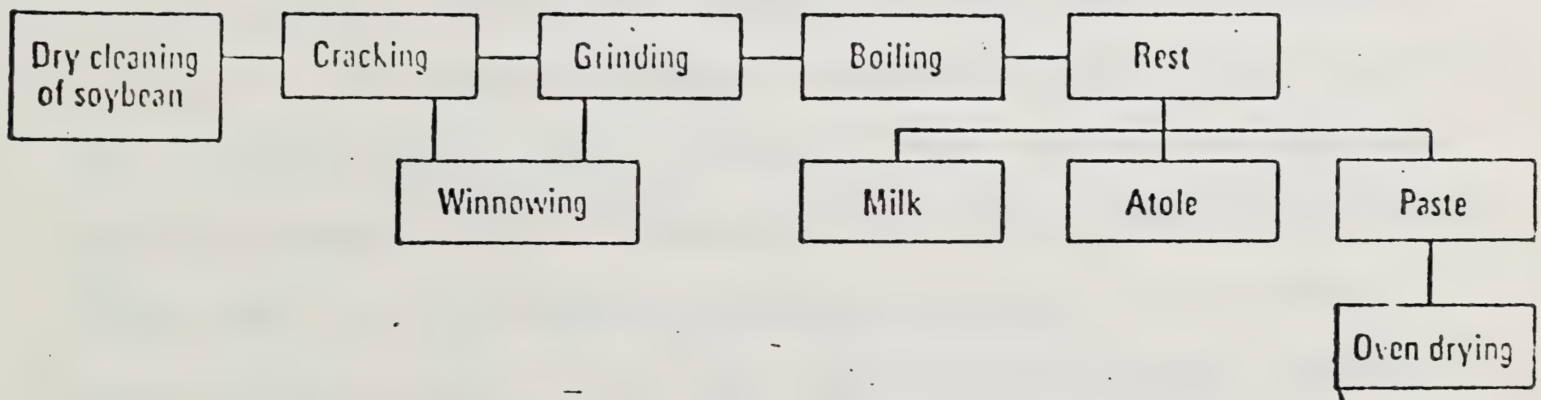

FIG.1. Flow chart of modified USDA process.

Commercial Developments of Soy-Based Food Products

We recognize that the commercial utilization of soy foods is not the primary object of this report; however, Mexico is unique in the efforts being made both by government and industry to introduce soy products into the Mexican diet, thus it was felt important to give a brief description of the products being promoted through retail outlets.

In 1973, the Mexican government inaugurated a group of soy supplemented meat products under the name of PROTEIDA. Meat products were formulated with approximately 25 percent texturized soy protein (TSP) and 75 percent ground meat (1). For example, one product consisted of a precooked patty called "milanesa." This patty required no refrigeration and was developed by the National Nutrition Institute. The various products utilized textured soy proteins from defatted soy flour purchased by the Government from private Mexican firms and were formulated and packaged in a government packing house, then distributed by the government (Jose L. Camacho, National Nutrition Institute, private communication, 1976).

During the period since 1973, other textured soy products have been independently manufactured and distributed in Mexico. For example, Miles/Worthington have produced a beef-flavored TSP called ALBORADA, which has received good acceptance by the public and is being sold in leading supermarkets as well as restaurants, hospitals, meat packaging plants, and canned food producers.

At present, soy consumed as human food amounts to only about 30 tons per day:

Full-fat soy flour	18 tons
Soy milk and similar products	6 tons
Texturized soy protein	6 tons

The projected increase in consumption of these three basic products in 100 tons per day for the current year (A. J. Pontecorvo, LIFE Newsletter, May 1976).

Another TSP product, PROTOLEG, is the oldest product on the market. Its producer, Industrial de Alimentos, is now the largest manufacturer of soy protein products in Mexico. This company also produces and markets a soy beverage powder called SOYACYT. The product is a direct application of a beverage process developed at the Northern Regional Research Center, ARS, USDA, Peoria, Illinois, by G. C. Mustakas et al. and introduced to the company through his visit there in 1971.

The Mexico City regional office of the American Soybean Association through Mr. Gilford Harrison, Director, has become the center of great interest in soy protein products for human consumption. Through their development activities, the demand for soy protein products in Mexico have greatly improved during the last few years.

The largest volume of sales is in soy flour for baking. The tortilla industry consumes some 60 percent of the total. The remaining 40 percent is about evenly divided between TSP and beverage or milk-like products. The largest bakery in Mexico, BIMBO, plans to start producing a soy-based milk substitute containing sweet whey powder.

According to Mrs. Orellana, Nutrition Director of Latin America, American Soybean Association, considerable promotion of soy protein foods is taking place in her cooperation with several sponsoring government agencies (Mrs. Orellana, private communication, 1976). For example, soybeans are being mixed in a 1/1 ratio with other local beans, soaked, and cooked. She claims that cooking soybeans in a mixture of other beans reduces cooking time, gives a softer texture, and furthermore that the mixed beans take on the flavor and color of the nonsoybean used. About 45 minutes cooking time is required in a pressure cooker and about 2-1/2 to 3 hours in an atmospheric cooker, depending on the elevation. Salt, garlic, onion, and bicarbonate of soda are some of the additives used in their cooking process. Soy flours are being promoted as cereal gruels and in "atole" foods.

The Mexican government is sponsoring a social security program "Seguras Social" to develop better nutrition among the poor. The soybean is one out of eight nutritional food groups that is being promoted in the nationwide effort (600,000 families).

In Honduras

There is no commercial production of soybeans in Honduras, but since 1973 soybean production has been studied by several government, institutional, and private groups in Honduras. Experimentation has been conducted by the Ministry of Natural Resources, the Pan American School of Agriculture in Zamorano, and by the fruit companies, United Brands and Castle, Cooke, and Co., located in La Lima and La Ceiba, respectively. At present, there is no governmental policy or laws regulating cultivation of soybeans in Honduras, but the government is becoming increasingly interested in large-scale production due to the success of the growing experiments (Storms, Gayle E., Nutritionist CARE/Honduras, private communication, 1976).

The government of Honduras is embarking on a 5-year production program mainly for oil extraction and animal feed for domestic use. Through an A.I.D. nutrition loan, a 3-year Soya Project will begin in 1977. The project has three stages: production, consumption, and feasibility studies for commercialization of soya. The production stage involves cultivation at the "small farmer" level through cooperatives for home consumption purposes. The consumption stage is the home consumption involving the same groups who produced the soya. The feasibility studies will focus on the commercial introduction of soybeans through soy flour, soy milk, fortification of flour products and tortillas, and methods of incorporating the soya into the local diet.

CARE/Honduras is now beginning small agricultural projects with Housewives Clubs in rural areas to introduce a means of providing foods to take the place of CARE foods now supplied to the school and preschool feeding programs. They are planting soybeans on a small scale and are experimenting with them in feeding centers, testing recipes and acceptability. Some of these recipes are given in the Appendix (Storms, Gayle E., private communication, 1976).

In Costa Rica

No soybeans are produced or consumed as a food, although experimentation is being carried out at the University of Costa Rica and also with CARE (Storms, Gayle E., private communication, 1976). Costa Rica has a GNP of some 1.2 billion dollars, population of 2.1 million with a per capita income of $590, of which about 30 percent is spent on food. The government is starting a family assistance program to employ 500 nutritionists, financed by a 2-percent tax on payrolls (Mustakas, G. C., Trip report to Jamaica, et al., March-April 1975).

The Ministry of Agriculture and IMAS, a national counterpart of CARE, are planting about 100 hectares of soybeans with farmers in Guanacaste. In conjunction, the Costa Rican Food Research Center, CARE is negotiating a special grant with AID to utilize a Brady Soybean Extruder to process the beans from the crop now being grown (at least 210,000 lb. of beans expected) (Bachman, Kurt, private communication, 1976).

According to an article by Helen Hennessy (CARE, private communication) reporting on the CARE program in Costa Rica, housewives are now using soybeans in their tortillas. Also the program is teaching children and their mothers how to substitute soybeans for black beans which are more expensive and contain only half the protein.

In Panama

Panama grows no soybeans and has no utilization of soybeans in foods. They use fairly large quantities of soybean meal (39,000 tons imported in 1973) for animal feeding and some firms are interested in using defatted soy flours and textured soy products for foods (Mustakas, G. C., Trip report, March-April 1975).

In Dominican Republic

Soybeans are not grown or utilized as food in this country. About 2,500 acres were planted in 1974 on an experimental basis (no figures for 1975-76). During a visit there in March 1975 (Mustakas, G. C., Trip Report, March-April 1975), Mustakas talked with oilseed processors (Industria Mancera, Industria Lavador) who are now crushing peanut and copra, but soybean and cottonseed oils are imported. Industria Lavador's oilseed plant plans to increase production to 300 tons/day and with the expansion, hope to produce soy food products in some form.

In Jamaica

Soybeans are not grown in Jamaica and there is no utilization of soybeans at the home or village level. However, in an ASA-FAS sponsored visit there in March 1975 (Mustakas, G. C., Trip Report, March-April 1975), Mustakas found considerable interest in utilizing soybeans for school lunch programs, and we met with Mr. Bal Lewis, General Manager of Nutrition Products, Ltd., Ministry of Education, in their government food plant which is manufacturing and distributing milk and vegetable-meat pie products for a school lunch program in the Kingston area. They hoped to expand the program to 52,000 children per day with an eventual target of reaching the whole island of Jamaica, which has 700,000 children. Milk is made from nonfat dried milk and soy oil (deodorized). A highly accepted meat pie is produced with meat and vegetables. The crust is made with wheat flour containing 6 percent soy flour and hydrogenated soy oil. Beef patties were also produced and distributed. They were most interested in textured soy protein for meat replacement and soy beverages for milk extenders.

Jamaica Nutrition Holdings, Ltd., the central government buying agency, is very interested in soy food products for government feeding programs. I. S. Joseph, a U.S. firm, is building a 300 ton/day soybean plant which will be 60 percent government owned; approximately 22 miles from Kingston, the plant is due for completion in 1976.

In Haiti

Soybeans are not grown or utilized as food at the home or village level in this country. In March 1975, Mustakas visited with Mr. Dan Grant, Commercial Officer, American Embassy in Port-au-Prince (Mustakas, G. C., Trip Report, March-April 1975). Haiti is the poorest country in the Caribbean with a GNP of only $600 million and a population of 5.3 million. The country has serious caloric and protein deficiencies in the diet of its people. Food staples are beans, rice, bananas, yucca (cassava), coconut, and bread. Mr. Grant and others attending our conference on soybean foods showed great interest and were given complete information on our NRRC simple village process for making full-fat soy flour.

In Trinidad

Soybeans are not grown or utilized as food at the home or village level in this country. Local experiments in growing soybeans are being conducted under a project agreement between the governments of West Germany and Trinidad and Tobago (Mustakas, G. C., Trip Report, March-April 1975). In Trinidad, we found considerable interest in soybeans but no processing plants. A chain of supermarkets (Hi-Lo) is selling a soy protein beefburger which contains 25 percent textured soy flour.

Much interesting information was received recently from Mrs. Ursula Lashley, home economist with the John Donaldson Technical Institute which I quote from her letter as follows:

"Originally, it was contemplated that Soya would be cultivated here in Trinidad and Tobago to alleviate the edible oil problem, since coconuts, which traditionally provided all the edible oil in the country, was plagued with a multitude of field and economic problems. As a by-product of oil extraction, soya meal would be used as livestock feed, thereby reducing, to some extent, the dependence of livestock farmers on foreign soya supplies. An exploratory extraction exercise conducted by Lever Brothers, an industrial concern in this country in December 1975, yielded recovery of both oil and meal of over 95% from a 15,000 lb lot of soya beans processed.

"However, the stimulation of consumers' awareness to the need for a cheap source of high protein food; the inconsistency in the logic of consuming soya protein via livestock and the versatility of the bean itself as a multi-purpose food have given rise to complete review of the original objectives of Soya cultivation here and entirely new dimensions have been assumed in the exercise.

"Crop production personnel in the Chaguaramas Agricultural Development Project (CADP) and Home Economists at the John Donaldson Technical Institute have been collaborating to refine, demonstrate, and promote the production and utilization of locally grown soya. To this end, the agronomists have published a booklet on the growing of Soya while the Home Economists have produced several booklets and pamphlets with information on preparing dishes from soybeans. A booklet is about to be published.

"It might be of interest to you to note that Guyana, St. Kitts, and Trinidad and Tobago have embarked upon a programm of Corn/Soya production in the hinterland of Guyana as part of the Caribbean Food Plan.

"It is envisaged that soon a programme will be formulated with the Extension Division in the Ministry of Agriculture, Lands and Fisheries to exhibit soya growing at vantage points in rural Trinidad and Tobago with accompanying demonstrations by Home Economists in food preparation. I am currently working in conjunction with the Government Broadcasting and Film Unit to produce a documentary on "Soya for Food." I am dealing with basic steps Cleaning, Soaking, and Blanching: I also hope to deal with the preparation of: (1) Soy Milk, Soy/Choc Milk

(2) Soy Fudge. Soy/Choc Fudge - A candy

(3) Soy/Almond Paste - Marzipan

(4) Soynut butter

(5) Soy Nuts

(6) Curried Soybeans

(7) Phulouri (An East Indian Dish using Dhal)"

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SOYBEAN FOOD USES AND PRODUCTION IN NORTH AMERICA

In the United States

Soybeans are not a traditional food for the people of the United States, but great changes in the uses of soybean crops have occurred in recent years.

During the early part of the crops history in the United States, two-thirds of the acreage was used for forage; the remaining third was harvested for beans which perhaps were also used for animal feeds. Today, the United States, the largest soybean producer in the world, uses more than 50 percent of the soybeans produced for oil, 30 percent for exports, and the remaining for seeds and feeds (Table I). The defatted meal is one of the basic protein sources for our vast livestock production. In the food processing industry, soybean flour is a valuable ingredient for bakery products. Other food products from processing soybeans are: soybean grits, textured protein, soybean oil, soybean meal, and lecithin.

A very small amount of whole soybeans, however, is consumed as food in the United States. About 1 percent of the U.S. population is Oriental (U.S. Bureau of the Census, 1975); even after living in the United States for generations, the Orientals have kept their food habits. Varieties of Oriental foods, either imported or made locally, are available in Chinatown or specialty shops. Soybean curd is the most popular soybean food and is always locally made by the traditional method.

Table 1. Supply and Disposition of Soybeans in the United States, 1967-1976*

Item	Year Beginning September								
	1967	1968	1969	1970	1971	1972	1973	1974	1975
	Million bushels								
Supply:									
Stocks	90.1	166.3	326.8	229.8	98.8	72.0	59.6	170.9	185.0
Production	976.4	1,107.0	1,133.1	1,127.1	1,176.0	1,270.6	1,547.2	1,214.8	1,521.0
Total	1,066.5	1,273.3	1,459.9	1,356.9	1,274.8	1,342.6	1,606.8	1,385.7	1,706.0
Disposition:									
Crushing	576.4	605.9	737.3	760.1	720.5	721.8	821.3	701.3	865
Exports	266.6	286.8	432.6	433.8	416.8	479.4	539.1	420.7	565
Seed	48.6	47.3	48.5	48.1	51.0	60.8	56.1	57.2	
Feed	0.9	0.9	0.9	1.1	1.1	1.1	1.2	1.0	76
Residual	7.7	5.6	10.8	15.0	13.4	19.9	18.2	20.5	
Total	900.2	946.5	1,230.1	1,258.1	1,202.8	1,283.0	1,453.9	1,200.7	1,506

*Sources: Economic Research Service, USDA, August 1976, Fats and Oils Situation.

Processed tofu products, such as toufu kan and deep-fried tofu are frequently available. In the states of California and Hawaii, which with high Oriental populations, traditional soybean foods are often sold in the supermarkets. In the last few years, because of increasing interest in vegetarian diets, tofu and soybean milk have also become regular items in the nature food stores around the United States.

The amount of whole soybeans used as food in the United States, however, is still too small to warrant a separate mention in any official statistics.

The establishment of many vegetarian communes has also increased the consumption of whole soybeans as a food in the United States. Soybeans are usually the main protein source for the people of the commune. Some communes even plant their own soybeans. The most popular soybean foods made in those communes are soybean milk, tempeh, tofu, soybean ice cream, and soybean yogurt. Generally, they follow the traditional Oriental methods for making soybean milk, tofu, and tempeh, and then develop their own recipes to suit their taste.

"The Farm" in Tennessee, which has over 1,000 people, makes about 1,200 gallons of soybean milk, 300 pounds of tofu, 250 gallons of soy yogurt, and 600 pounds of tempeh weekly. They also eat whole cooked soybeans, plain or in a sauce. They roast them into soynuts, and make soyburgers, soy loaf, and soy sausage. From soybean oil, they make soy

mayonnaise, salad dressing, whipped cream, and dessert frostings. In winter, the beans are sprouted to be used as a vegetable. On the average, they eat soybeans in some form at least once a day, but often more. In 1975, they harvested and consumed 6,000 bushels of soybeans and 1,000 bushels each of pinto, kidney, and black beans.

In Canada

Canadians consume a fair amount of peas and beans, 5.1 kg. per capita yearly (FAO food balance sheet, 1964-1966); however, they do not use soybeans in their diet. Canada, like the United States, has a great number of Orientals as well as many vegetarians. The situation of soybean consumption as foods in Canada is quite similar to that in the United States.

Canadian soybean production, which began during World War II, is largely confined to southwestern Ontario. The major period of crop expansion occurred between 1947 when 61,000 acres were planted and 1957 when the area planted was 256,000 acres, primarily to alleviate a shortage of fats and oils (Canadian International Grains Institute, 1975). Future possibility for increase is limited because soybeans are not adapted to a large portion of the cultivated land in Canada. Canada produced 397,000 tons of soybeans in 1973 and 367,000 tons in 1975, with the area planted reduced from 77,000 acres in 1973 to 64,000 acres in 1975 (Economic Research Service, 1976). Canadian supply and distribution of soybeans from 1964-1974 are presented in Table 2.

Table 2. Soybean Supply and Distribution, Canada, 1964-1974*

Year beg. Aug. 1	Production Th. bu.	Imports Th. bu.	Supplies Th. bu.	Exports of beans Th. bu.	Processed for oil and meal Th. bu.
1964	6,976	16,457	23,433	3,179	19,541
1965	8,030	17,058	25,088	2,152	20,654
1966	9,012	16,295	25,307	3,599	19,876
1967	8,091	13,328	21,417	1,571	19,846
1968	9,027	12,469	21,496	1,123	20,054
1969	7,664	17,430	25,094	1,111	23,679
1970	10,398	15,690	26,088	772	23,443
1971	10,288	14,771	25,059	1,360	23,314
1972	13,779	10,986	24,765	1,066	22,507
1973	14,587	10,628	25,215	1,062	---
1974	10,362	11,306	21,668	1,055	23,601

* Source: American Soybean Association, 1975 Soybean Digest, Blue Book, March 1975.

References

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SOYBEAN FOOD USES AND PRODUCTION IN OCEANIA

In Australia

Soybean production in Australia averaged 25,000 bu. from 1962-1966, but increased to 2,094,000 bu. in 1974 (Am. Soybean Assoc., 1975). Unfavorable weather limits the expansion of soybean planting. Most of the current production is in Queensland, with the remainder in the New South Wales area. In 1970 Australia did import 70 metric tons of soybeans, used mainly for oil and feeds. Contacts from Australia are scanty and no information on soybean utilization as food has been obtained.

In New Zealand

According to Long (1963), output per man in New Zealand's agriculture is close to the highest in the world, and their major agricultural products are milk, wool, mutton, lamb, and beef. Available information indicates that New Zealand neither produces nor consumes soybeans.

References

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SUMMARY

Traditional Soybean Foods

Traditional foods based on soybeans have been limited to the Orient where soybean foods have been eaten by everyone--young and old, rich and poor. The kinds of soybean foods they like, the ways to prepare them, and the manner of consuming them are deeply imbedded in their culture. These traditional soybean foods are summarized as follows:

Soybean Milk

Soybean milk is the water extract of wet ground soybeans. It looks like dairy milk, and can be used as dairy milk; but it has its own characteristic odor and taste. Although soybean milk is the starting material for many other soybean foods, the direct consumption of soybean milk is only popular among Chinese.

Soybean Curd and Processed Soybean Curd Products

Tou fu, tofu, tubu, tahoo, touhu, tau foo, and dan fu are some of the phonetic renditions for soybean curd from different countries. Soybean curd is, perhaps, the most important and popular soybean food in the Orient. The curd, a cottage cheese-like product formed into a cake, is precipitated from soybean milk by calcium sulfate, vinegar, or other coagulating agents, and then transferred to a molding box to form a soft cake. Soybean curd has a bland taste so that it can easily be flavored with seasonings or blended with other foods. A variety of products processed from soybean curd are made by dehydration, freezing, and frying. These processed products have less moisture content and a more chewy texture than that of soybean curd itself.

Protein-Lipid Film

Tou fu pi, fu chok, and yuba are the traditional names for this product. It is the film formed over the surface of soybean milk when the milk is heated nearly to boiling. The cream-yellow film is air dried and made in the form of sheets, sticks, or flakes. The film is a very popular food item in the Orient.

Soybean Sprout

Huang tou ya (Chinese), or daizu no moyashi (Japanese) is produced by germinating soaked and drained soybeans in the dark for 1-2 weeks until the sprouts reach full growth (about 3-4 cm.). Soybean sprouts are often used in soups, steamed, or satueed for hot vegetable dishes. After cooking, they can also be used in salads.

Tempe (Tempeh)

Tempeh is an Indonesian fermented soybean product. The fermentation process is rather short and simple. Soaked and dehulled soybeans are boiled, drained, surface-dried, mixed with tempeh starter (*Rhizopus oligosporous* spores), wrapped in banana leaves or perforated containers, and then incubated at about 30°C. for 20 to 24 hours. At that time, the beans are bound together by mycelia resulting a cakelike product. When sliced and fried in oil, it has a pleasant flavor, aroma, and texture that would be acceptable to people of different cultures around the world. Tempeh-like product has also been made from the residue of making soybean milk and soybean curd. The product is known as tempe gembus in Indonesia.

Green Soybeans

Immature soybeans, mao tou, or edamame are widely consumed in the Orient as a seasonal vegetable. The most popular way to prepare is to boil the beans in the pods for 10-15 minutes in salt water. The pods are then removed before consuming.

Boiled Soybeans

Dry soybeans are soaked and boiled in water with seasonings, such as soysauce, and served as snacks. Sometimes, they are cooked with seasonings and meat to serve with regular meal.

Roasted Soybeans

Soaked or unsoaked soybeans are often roasted above open fire, or fried in oil to use as snacks.

Soybean Flour

Roasted soybeans are ground into flour which is then used in pastry. Soybean flour as processed in this country is not traditionally used in the Orient.

Soysauce

Soysauce (known as ciang yu in China, shoyu in Japan; tau yu in Indonesia, and tayo in the Philippines) is a dark brown liquid with a salty taste (16-18% salt) and a pleasant aromatic odor suggestive of meat extracts. It is made by fermentation from a combination of soybeans, wheat, and salt with a mixture of molds, yeast, and bacteria. Soysauce is the prominent all-purpose seasoning agent used in the preparation of Oriental foods as well as a table conditment.

Fermented Soybean Paste

Fermented soybean paste (miso in Japanese and chiang in China is also a common flavoring agent in the Orient. It has an aroma and salty taste similar to that of soysauce and is a brown paste resembling peanut butter in consistency. Fermented soybean paste is made from soybeans and salt with or without a cereal by a process comparable to that used in soysauce. The product has been produced and consumed in many Oriental countries for centuries. In some countries, a variety of bean pastes may be made by varying the ratio of bean to cereal, salt content, fermentation time, or addition of other ingredients such as hot pepper.

Fermented Whole Soybeans

Toushih or hamanatto is made by fermenting whole soybeans with a strain of *Aspergillus*. The fermented beans can be used as a condiment with bland foods such as rice porridge, or they can be cooked with vegetables, meats, and seafoods as a flavoring agent.

Natto

Natto, a fermented soybean food in Japan and Korea, is made from whole soybeans by fermentation with *Bacillus subtilis*. The process is simple and quick, similar to that of tempeh fermentation except that a different microorganism is used. Natto is well known in Japan, but it is not widely consumed because of its characteristic strong odor, flavor, and its slimy appearance.

Fermented Soybean Curd

Fermented soybean curd known as Chinese cheese or sufu is made from cubes of soybean curd by the action of a mold, Mucor or Actinomucor; the molded curd cubes are then aged in a salt solution resulting a soft cheese-type food. Sufu is made and consumed only by Chinese.

Experimental Soybean Foods

In recent years, various approaches have taken to incorporate soybeans into native diets of countries that do not traditionally use soybeans as foods. The following soybean products have been in use:

Whole Soybeans

The soybeans are soaked, drained, boiled in water with the addition of salt, baking powder, or sodium bicarbonate, and then simmered for 1-3 hours. The cooked beans are used in salads, soups, stews, and casseroles--anywhere one would use any kind of bean.

Soybean Paste

The paste is made by first soaking the beans and then grinding to a creamy paste. For use in the local diets, it is usually mixed with cereals. The paste may be made from boiled soybeans and used in the recipes for spread or pie-filling.

Soy Flour

Soybean flours, full-fat or defatted, have been incorporated into many native diets. They are frequently combined with cereals in preparing familiar native foods. Soy flour seems to be the most versatile soy product to be used in the diets for the people outside the Orient.

Soy Beverage

Traditional Oriental soybean milk and soy beverage made from whole soybeans have been introduced into various countries.

Soybean Production and Consumption

The area and production data in Table 1 are based on information just released by FAS, USDA rather than the figures cited in the text, since the FAS report contains more detailed and up-to-date information.

World soybean production is concentrated in three countries, the United States, Brazil, and China; however, soybeans are grown in small areas throughout the world. While the U.S. soybean production in 1976 is down nearly 18% from the 1975 output, Brazilian production is up about 15% from the previous year. The production in the People's Republic of China remains the same. Among other producers, Argentina and Indonesia produce significant amount of soybeans, but only in Argentina does there appear to be a great interest in expanding the soybean planting.

The FAO food balance sheets, 1964-1966 (1971) have been the chief source for consumption data, although more recent information was received from a few individual countries. In general, food patterns of each nation have remained unchanged. For comparitive purposes, soybeans utilization data for soybean-consuming countries, given in the FAO report, are summarized in Table 2.

Table 1*

SOYBEANS: AREA AND PRODUCTION IN
SPECIFIED COUNTRIES AND THE WORLD, ANNUAL 1970-76 1/

Continent and Country	Area 2/							Production						
	1970	1971	1972	1973	1974	1975 3/	1976 4/	1970	1971	1972	1973	1974	1975 3/	1976 4/
	(In 1,000 hectares)							(In 1,000 metric tons)						
North America:														
Canada	136	149	164	190	180	158	146	283	280	375	397	280	367	291
Mexico	140	155	240	306	255	355	150	240	250	375	510	420	625	256
United States 5/	17,098	17,281	18,494	22,580	21,193	21,694	19,992	30,675	32,006	34,581	42,108	33,062	41,406	34,012
South America:														
Argentina	26	38	63	160	339	369	442	27	59	78	272	496	485	695
Brazil	1,319	1,716	2,840	3,615	5,143	5,824	6,227	1,509	2,077	3,700	5,011	7,876	9,892	11,344
Bolivia	1	1	1	2	6	6	6	1	1	1	3	8	10	10
Chile	(6/)	2	2	1	1	2	2	1	3	3	1	1	2	2
Colombia	58	58	58	54	57	88	60	95	106	122	114	114	169	136
Paraguay 7/	40	54	76	92	120	150	180	52	75	97	122	185	218	230
Peru	(6/)	1	1	1	2	3	3	1	1	1	3	5	8	7
Ecuador	(6/)	1	1	1	2	8	12	1	1	1	2	3	10	14
Europe:														
France	0	0	0	0	2	2	4	0	0	0	0	4	5	10
Spain	2	2	2	13	18	20	22	3	2	3	13	39	16	35
Bulgaria	9	18	14	19	25	31	58	8	16	13	16	18	62	100
Hungary	0	0	0	0	15	25	40	0	0	0	0	14	41	55
Romania	79	146	109	183	239	122	200	91	165	186	244	298	195	250
Yugoslavia	4	5	4	9	8	15	32	5	4	6	13	14	25	50
USSR	860	868	905	838	830	811	850	603	535	258	424	357	780	500
Africa:														
Ethiopia	10	10	10	10	10	10	10	6	6	6	6	6	6	6
Nigeria 8/	- -	- -	- -	- -	- -	- -	- -	11	1	4	1	1	1	1
South Africa 7/ 9/	14	9	12	9	13	13	12	4	2	3	5	21	20	19
Tanzania 10/	5	5	5	5	5	5	5	4	4	4	4	4	4	4
Uganda	5	5	5	5	5	5	5	3	3	3	3	3	3	3
Zaire	2	2	2	2	2	2	2	2	2	2	2	1	1	1
Asia:														
Burma	20	20	23	21	21	21	22	13	13	14	15	15	14	14
China, People's Republic	8,000	8,100	8,400	8,500	8,800	9,200	9,200	6,900	6,700	6,500	8,000	9,500	10,000	10,000
China, Republic of Taiwan	40	40	36	36	45	45	45	65	61	60	61	67	62	59
India	24	30	32	35	40	40	40	11	18	20	25	30	35	35
Indonesia	694	666	696	750	753	758	753	498	475	518	507	550	575	575
Iran	6	8	7	14	30	54	54	6	7	10	22	36	70	70
Japan 5/	96	100	89	88	93	87	87	126	122	127	118	133	126	120
Khmer Republic	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Korea, North	395	400	405	405	405	405	405	228	230	235	235	235	235	235
Korea, Republic of 7/	298	277	284	312	286	275	289	232	222	224	246	319	311	311
Philippines	2	2	1	2	3	8	12	1	1	1	2	2	6	10
Thailand 7/	83	75	81	95	102	115	126	70	67	80	100	115	140	155
Turkey	11	7	5	5	4	4	4	12	11	13	7	9	9	9
Vietnam 11/	34	36	36	36	36	36	36	15	17	19	18	18	18	18
Oceania:														
Australia 6/	5	7	18	28	41	46	28	5	9	34	38	63	74	31
Estimated world total	29,560	30,338	33,170	38,466	39,173	40,856	39,605	41,811	43,556	47,985	58,671	54,326	56,030	59,700

1/ Years shown refer to years of harvest, Southern Hemisphere crops which are harvested in the early part of the year combined with those of the Northern Hemisphere harvested the latter part of the same year.
2/ Figures refer to harvested areas as far as possible. 3/ Preliminary. 4/ Forecast. 5/ Hectarage harvested for beans. 6/ Less than 1,000 hectares. 7/ Planted area.
8/ Quantities purchased by the Nigerian Marketing Boards for exports. 9/ European farms only. 10/ Sales. 11/ Includes former South Vietnam.

Foreign Agricultural Service. Prepared or estimated on the basis of official statistics of foreign governments, other foreign source materials, reports of U.S. Agriculture Attaches and Foreign Service Officers, results of office research and related information.

*Foreign Agriculture Circular FOP 17-76, November 1976.

Table 2. Utilization of Soybeans by Soybean-Consuming Countries (1964-1966)*

	Production (1,000 ton)	Import (1,000 ton)	Domestic Utilization Food	Feed	Oil	Per Capita Consumption as Food kg. Per Year
			(1,000 ton)			
Asia						
China, People's Republic	11,040	---	5,123	662	3,312	6.7
China, Republic of	62	169	88	---	143	1.1
Indonesia	367	---	294	29	22	2.8
Japan	223	1,931	497	16	1,594	5.1
Korea(s)	166	3	142	6	---	5.0
Malaysia	---	17	16	---	---	2.6
Philippines	1	18	6	---	13	0.2
Singapore	---	16	8	---	---	4.3
Thailand	41	---	17	---	14	0.6
Vietnam	13	---	13	---	---	0.3 to 0.4
Africa						
Nigeria	16	---	4	---	---	0.1
Tansania	3	---	2	---	---	0.2
Uganda	1	---	1	---	---	0.1
Latin America						
Brazil	474	---	95	---	263	1.2
Mexico	58	3	12	---	49	0.3

*Food and Agriculture Organization of the United Nations, 1971, Food Balance Sheets. 1964-1966 Average.

In Asia, significant amounts of soybean produced are consumed directly as food; however, the world food consumption of soybeans is low; most of the soybeans produced are used for oil and feeds. Even in the two major countries that do consume soybeans, China and Japan, the percentage of soybeans used as food is low; only 15% of 889,000 tons of soybeans used in the Republic of China in 1975 are for food; in Japan, only 22% of more than 3,000,000 tons of soybeans used yearly are for food.

In recent years, the U.S. has distributed cereal-soy blends to many countries. It is assumed that these mixtures have been consumed as food in the recipient countries. The amounts of cereal-soy blends distributed and the recipient countries are summarized in Table 3. Table 4 indicates the amounts of full-fat soy flour the U.S. exported during 1974 and 1975. This, too, is expected to be consumed as food.

Table 3. Amounts of Cereal-Soy Blends Distributed Under Title II, Public Law 480 in Fiscal Year 1974

Country	Commodity (1,000 lb)		
	CSM	CSB	WSB
Africa	49,660	34,004	26,344
Botswana	8,864	2,185	---
Burundi	120	35	---
Cameroon	200	355	205
Central African Republics	---	180	---
Chad	688	---	---
Congo	---	---	788
Dahomey	46	---	116
Ethiopia	4,458	36	---
Gabon	---	---	66
Gambia	213	100	---
Ghana	2,244	1,137	1,368
Ivory Coast		365	867
Kenya	155	1,819	---
Lesotho	2,458	227	610
Liberia	388	572	323
Malagasy	188	182	---
Mali	840	66	---
Mauritania	80	5,799	---
Morocco	509	3,558	10,596
Niger	33	45	---
Nigeria	200	6,821	329

continued--

Table 3.--Continued

Country	Commodity (1,000 lb)		
	CSM	CSB	WSB
Rwanda	100	200	1,458
Senegal	1,318	---	---
Seychelles	129	---	---
Sierra Leone	556	1,356	149
Somali Republic	---	---	2
Sudan	---	2,454	---
Swaziland	---	105	---
Tanzania	2,299	5,419	---
Togo	---	340	2,923
Tunisia	3,366	6,544	2,883
Upper Volta	197	515	---
Zaire	199	---	---
Zambia	22	133	---
Sahel-Regional	19,810		
Europe		14	
Malta	---	14	---
Near East-South Asia	45,191	32,326	40,186
Bangladesh	10,888	---	2,581
British Solomon Islands	115	---	80
Egypt	1,394	2,229	---
Gaza	159	640	3,481
India	30,965	27,626	17,092

continued--

Table 3.--Continued

Country	Commodity (1,000 lb)		
	CSM	CSB	WSB
Jordan, E.	156	170	310
Jordan, West Bank	525	119	247
Nepal	989	1,542	193
Pakistan	---	---	685
Sri Lanka	---	---	6,994
Turkey	---	---	7,959
Yemen	---	---	126
East Asia	6,362	24,015	12,435
Cambodia	70	30	---
Indonesia	110	---	9,167
Korea	317	521	---
Laos	857	165	1,449
Malaysia	22	---	192
Philippines	4,933	22,660	382
Singapore	10	---	330
Vietnam	43	639	915
Latin America	51,789	34,171	41,560
Antigua	---	18	---
Bolivia	1,592	2,997	---
Brazil	18,753	5,656	2,442
British Honduras	149	---	43

continued--

Table 3.--Continued

Country	Commodity (1,000 lb)		
	CSM	CSB	WSB
Chile	---	421	5,386
Colombia	11,346	2,444	10,931
Costa Rica	526	1,714	228
Dominica	---	100	---
Dominican Republic	1,442	6,987	7,520
Ecuador	5,791	498	2,905
El Salvador	2,880	896	1,725
Guatemala	381	2,506	773
Guyana	256	70	---
Haiti	780	2,392	2,655
Honduras	376	1,142	3,429
Jamaica	813	17	39
Nicaragua	2,856	2,891	443
Panama	579	1,755	796
Paraguay	2	---	---
Peru	3,155	1,607	2,170
St. Kitts	---	60	---
St. Lucia	83	---	25
St. Vincent	29	---	50
Grand Total	153,002	124,530	120,525

Definitions: CSM (corn soya mix); CSB (corn soya blend); WSB (wheat) soya blend).

Source: Food for Peace Program 1974 Annual Report, U.S. Government Printing Office, Washington, D.C., 1976.

Table 4. U.S. Exports of Full-Fat Soy Flour

Destination	1974	1975
	1,000 lb	
Canada	146,974	111,409
Mexico	72,679	10,201
Salvador	1,099	2,581
Dominican Republic	2,222	3,295
West Germany	8,716	76
Switzerland	406	1,408
Portugal	4,566	66
Yugoslavia	0	3,442
Greece	5,654	3,234
Syria	0	18,637
Saudi Arabia	0	3,941
South Vietnam	2,310	0
Hong Kong	2,413	300
Australia	3,757	2
Egypt	26,479	11,034

Source: U.S. Foreign Agricultural Trade Statistical Report, Calendar Year 1975, Economic Research Service, U.S. Department of Agriculture, Washington, D.C., May 1976.

RECENT SIMPLE SOYBEAN PROCESSES, OTHER THAN TRADITIONAL

SIMPLE VILLAGE PROCESS FOR PROCESSING WHOLE SOYBEANS

During the 1960's the Northern Regional Research Center, ARS, USDA, developed a simple hand process for converting soybeans to a nutritious full-fat soy flour. The process was expressly designed for villages in foreign lands where skilled labor, electric power, and steam were not available.

Early studies showed that initial moisture was a highly significant factor in cooking rate. Overnight-soaked beans, which reached moisture contents of 62-68 percent, cooked rapidly. Cracking the beans was not necessary to achieve a rapid cooking rate. Of the methods tried, water immersion looked the best for rapid cooking and simple control. This method yielded a nutritive product and could be adapted to hand operation by untrained people.

Equipment

Table 1 lists the hand machinery for the process, capacities, and source. Capacities shown in the table are based on the use of hand power. Mechanical power can increase these capacities. For example, a 1/4 h.p. motor could double the capacity of the hand grinder.

Process

The basic steps in processing whole soybeans are outlined in Figure 1, and details for producing 136 kg. (300 lb.) of soy flour per day in Figure 2.

TABLE 1.--Equipment and cost information on making soy flour by hand process
[Capacity 136 kg. (300 lb.) soy flour per 8-hr day]

Process step	Equipment needed	Capacity of equipment basis: soybeans — Kilograms	Capacity of equipment basis: soybeans — Per time	Source[1/]
1. Soaking the beans	Four 208-liter (55 gal.) galvanized drums, plus 24 heavy porous cotton bags (about 46 by 115 cm.)	172	Day	Generally available
2. Immersion cooking	Heavy gauge galvanized steel tank, 200-liter capacity	90	Hour	Generally available
3. Air drying	Cloth, paper, or flat trays	--	--	Generally available
4. Hand cracking	Corn crusher, type S	--	Hour	Generally available
5. Winnowing (dehulling)	Hand grain winnower, type A-1	45	Hour	CeCoCo Chuo Boeki Kaisha Central Commercial Co., Osaka-Fu, Japan
6. Hand grinding	Flour grind mill, type D (2 mills)	9	Hour per mill	CeCoCo Chuo Boeki Kaisha Central Commercial Co., Osaka-Fu, Japan

1/ The mention of firm names or trade products does not imply that they are recommended by the U.S. Department of Agriculture over other firms or similar products not mentioned.

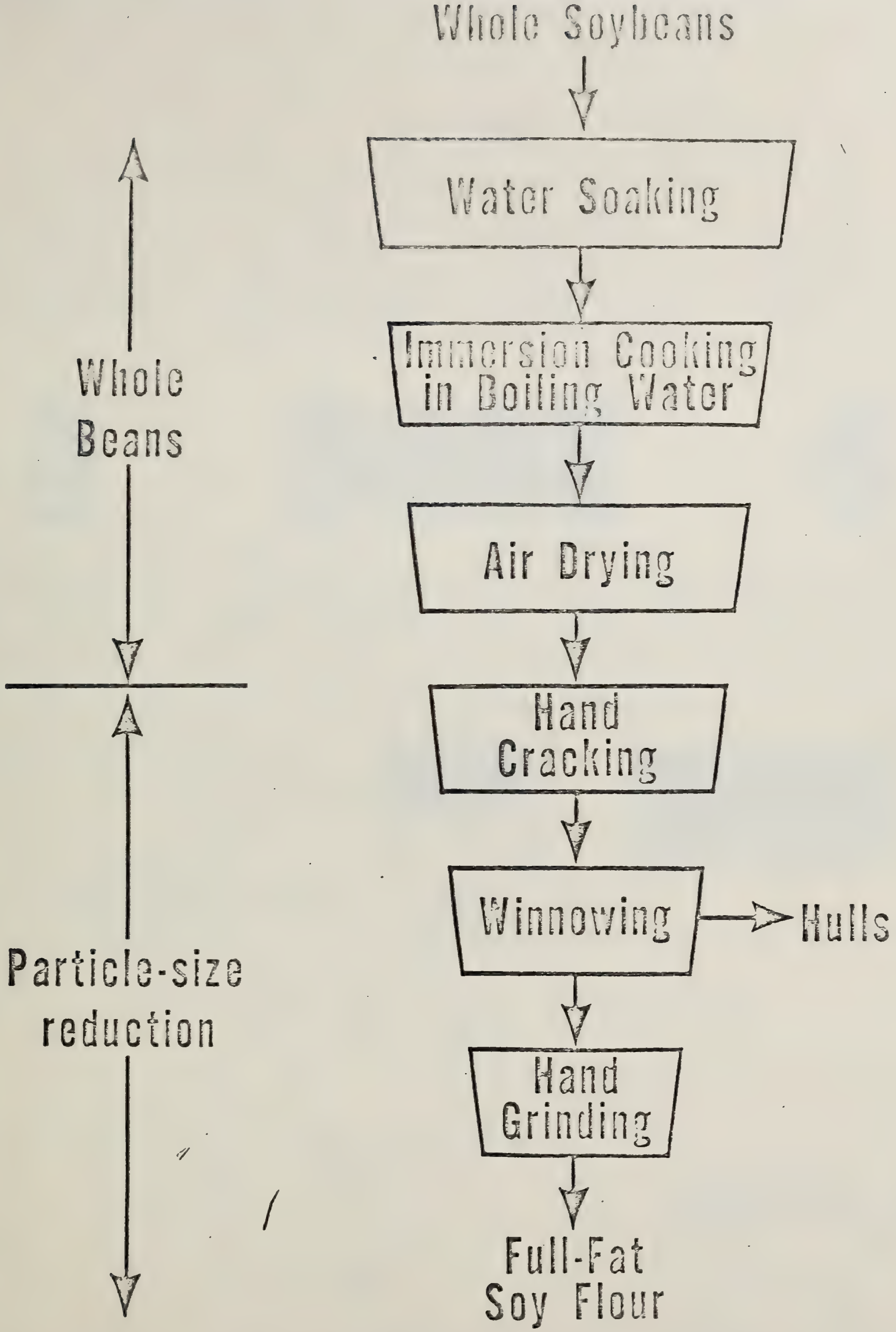
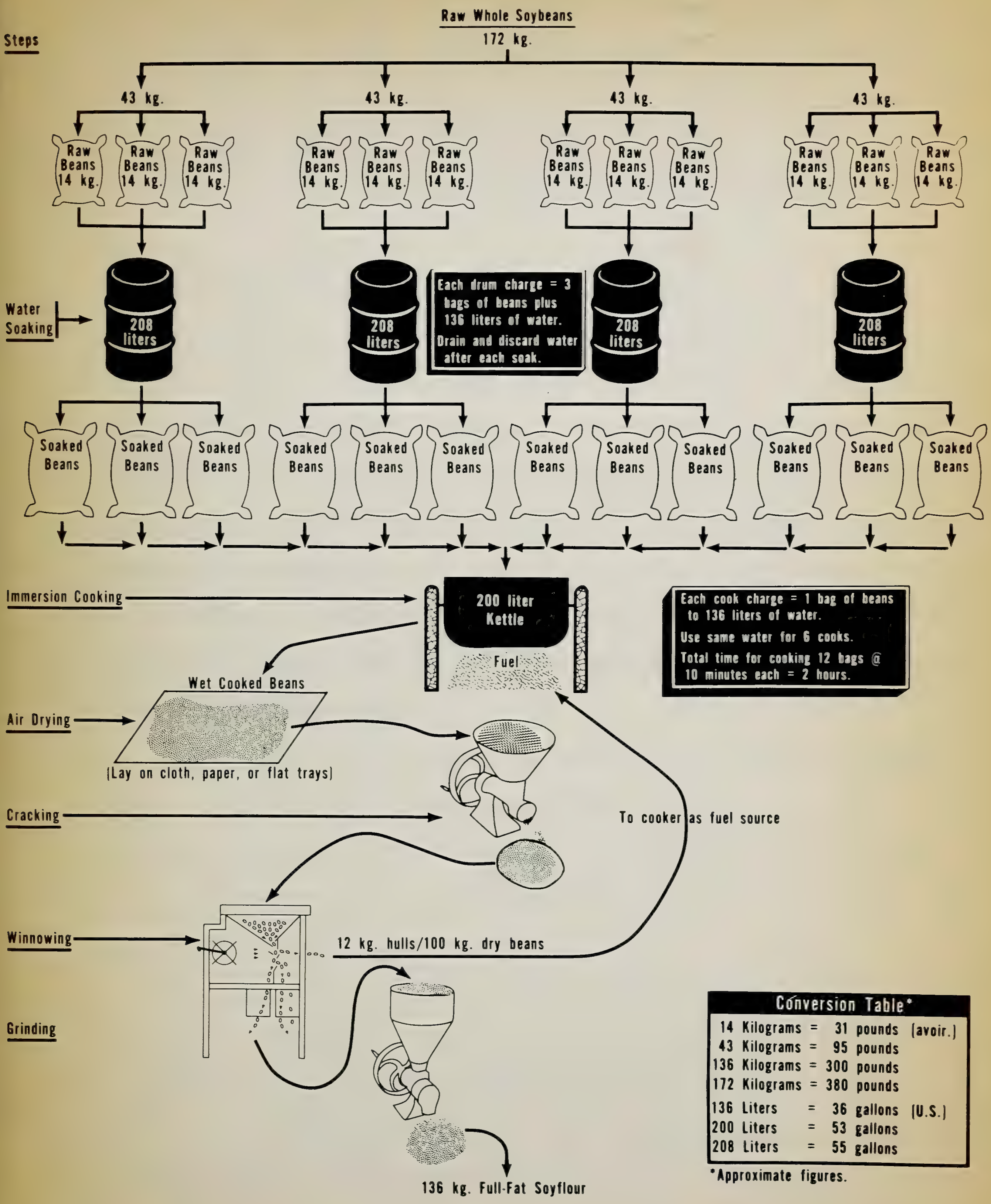


Figure 1.--Flow sheet of a simple method for preparing a full-fat soybean flour.



Conversion Table*

14 Kilograms	=	31 pounds	(avoir.)
43 Kilograms	=	95 pounds	
136 Kilograms	=	300 pounds	
172 Kilograms	=	380 pounds	
136 Liters	=	36 gallons	(U.S.)
200 Liters	=	53 gallons	
208 Liters	=	55 gallons	

*Approximate figures.

Figure 2.--Flow sheet showing amounts for producing 136 kg. (300 lb.) of soybean flour per day.

Whole soybeans are soaked in water of drinking quality for several hours, drained, cooked in boiling water to cover, drained, air-dried, cracked, dehulled, and finally ground to flour. Of the original bean solids, 7 to 9 percent is lost in soaking and cooking.

The six steps are discussed below and illustrated in Figure 3, A to F.

Step 1.--Soaking the Beans

If possible, start soaking the beans before sunrise. This allows as much daylight time as possible for the drying step. Fill a cloth bag, or a perforated basket one-quarter to one-third full with soybeans and lower it into fresh water in a container, such as a 208-liter (55-gal.) drum. The water temperature should be 75° F., or less, to minimize growth of microorganisms.

To improve the flavor of the beans slightly, add 1 kg. of sodium bicarbonate (baking soda) to 100 kg. of soak water. Baking soda, however, does not have to be added.

After 4 to 6 hr. of soaking, the beans will have swollen to about twice their size and will contain more than 40 percent water. This soaking is needed for uniform cooking. Lift the beans out of the soak water, drain briefly, and put them into the cooking pot (Fig. 3, A).

Step 2.--Immersion Cooking

Cook the beans, still in the bag, in water at full boil for 10 min. Cooking can be done in an open pot over an open fire. In high altitudes, up to 10,000 feet, the cooking period at full boil should be about 15 min. This cooking is necessary to make the beans safe for eating but does not remove or destroy protein.

Figure 3.--Processing whole soybeans: A, cooking; B, air-drying; C, cracking cooked, dried beans; D, winnowing to separate hulls; E, diagram of winnower construction and operation; and F, hand grinding meats to flour.

Lift the bag of beans out of the boiling water and allow to drain for a few minutes.

Cooking water can be reused about six times. The soybean hulls removed later in the process can be used as fuel.

Step 3.--Air Drying

After the beans are cooked, spread them out to dry in the air (Fig. 3, B). The area required for drying soybeans in a single layer is about 0.5 square meter per kilogram of dry soybeans, or a total area of 86 square meters (103 sq. yd.) for 1 day's production.

Drying conditions required for preventing mold or bacteria growth are discussed under Sanitation Requirements.

The water content at the end of drying should be low enough to permit good separation of hulls in the cracking step (about 9 percent or less). A simple impact test may be used as a guide to determine when the beans are dry enough for cracking. In this test, place a few beans on a flat hard surface and hit sharply with a small mallet or a flat stone. The beans should break easily with clean separation of the hull.

Ideally, soy flour should be produced during the driest season. If poor drying conditions exist because of wet weather, high humidity, and lack of sun, make changes in the drying step by drying with heated air.

Step 4.--Hand Cracking

Crack the air-dried whole beans by using hand-operated equipment (Fig. 3, C). Cracking frees the hulls (seedcoat) from the seed. Now, remove the hulls.

Step 5.--Winnowing

Place soybeans in the winnowing (dehulling) machine and hand crank the blower (Fig. 3, D and E). The moving air lifts the light hulls and carries them to one side. The heavier meats (free of hulls) fall directly below. Put the rest through the machine again.

Step 6.--Hand Grinding

Hand grind the dehulled soybean meats (Fig. 3, F) to make the flour.

Sanitation Requirements

In all food processing operations sanitary conditions are necessary to ensure wholesome food products. Contamination of food can be prevented by strict observance of the following conditions.

Village Laborers

All workers must understand the need for maintaining clean, sanitary conditions. They must be in good health and keep their hands clean at all times.

Soaking

Use clean, pure water for soaking the beans. If the water is contaminated, boil before using. Do not reuse water to soak a second batch of beans. Examine the beans for insect or rodent contamination and wash the beans before soaking. Clean all equipment before using. Cover the soak pots during soaking. Wash all bags, soak pots, ropes, and utensils thoroughly with clean water after each use. Turn the bags inside out and expose to the sun to dry.

Cooking

Clean all cooking pots, utensils, and other equipment before using.

Drying

After cooking, spread the beans out in thin layers on clean paper, cloth, or trays in an area with good air circulation. Complete drying within 30 to 36 hr., with as much exposure to direct sunlight as possible. If air-drying cannot be finished within 36 hr., use heated air. If drying conditions are bad, the flour made from the beans will not be good. For example, with slow drying, high bacteria counts and putrefaction can develop in 2 days; flour from such beans might be contaminated with molds that could produce toxic products. If mold can be seen, throw the beans away. Keep the drying area as free as possible from dust or any kind of dirt. Protect the drying beans from rain and dew.

Milling

Clean the winnower, cracking mill, and flour mill at the beginning and end of each day.

Flour Storage

Store the flour in clean containers off the ground. Protect the containers and storage area against moisture, rodent, insect, and other possible contamination.

Quality of Product

Analytical data for typical full-fat soy flour produced by this process are shown in Table 2. Protein efficiency ratios[3/] of 2.0 and available lysine values in the range of 6 to 6.5 indicate good nutritional value.

The flour has been tested in many basic food formulas and food combinations in cooperation with USDA's Human Nutrition Research Division, Agricultural Research Center, Beltsville, Md. It has good flavor acceptability and stability. Types of food that were prepared include breads (with wheat and corn flour), cooked vegetable and stew dishes, cereal products (noodles, porridge), cooked desserts, and beverages for babies and young children (Table 3). In beverage use for infants, a flour-water dispersion of improved smoothness will be obtained if the flour is finer ground or if the mixture is homogenized.

Evaluation of Product in Formulas and Procedures for Family and Institutional Use in Developing Countries

Full-fat soy flours processed by the village method at Peoria were supplied to the Human Nutrition Research Division, ARS, USDA, at Beltsville for evaluation. Basic formulas, food combinations, and preparation procedures suitable for use by families and community groups were developed for flours made from soybeans.

3/ Determined by A. N. Booth, Western Regional Research Center, Agricultural Research Service, U.S. Department of Agriculture, Albany, Calif. 94706.

TABLE 2.--Analysis of full-fat soy flour

Constituent	Range
Protein, pct.	41 to 42
Crude fat, pct.	20 to 23
Ash, pct.	5 to 7
Moisture, pct.	6 to 8
Crude fiber, pct.	2.5 to 3.0
Urease activity, pH change	0.0 to 0.1
Nitrogen solubility index	15 to 20
Available lysine, pct. of protein	6.0 to 6.5
Protein efficiency ratio average	2.0 (Casein, 2.5)

TABLE 3--Yield and protein analysis of basic products[1/]

Product	Yield	Protein (Percent)
Milk	6-7 liter	4
"Atole"	2-3 liter	8
Pasta	2-3 kg.	18

1/ From 1 kg. soybean, adding ca. 9 liters water in the boiling process.

The maximum amount of soy protein flour to provide a palatable food product was determined. Formulas for soy flours included beverages and soups, main dishes, breads, cereal products, and desserts. Detailed formulas are given in the Appendices. All products were evaluated for appearance, texture, flavor, and acceptability by a panel at the Beltsville Agricultural Research Center and at Howard University.

The panel at the Research Center rated the palatability of most of the food products prepared with soy flours from fairly good to very good. The soy products rated very good were bean cake, creole eggplant, biscuits, cornbread with egg, corn meal squares, seasoned rice, rice-spinach, and puff-puff doughnut holes. Both the food formulations and panel results were published by Georgia C. Schlosser and Elsie H. Dawson in ARS 61-7 Bulletin, July 1969, Agric. Res. Service, USDA.

Implementation of NRRC Village Process

The Village Process has had a considerable impact in the field as indicated by its introduction overseas and the large number of requests for reprints. UNICEF purchased and shipped equipment to countries in Latin America, Asia, and Africa.

In July 1967, the government of Brazil requested that an ARS representative visit their country and demonstrate the Village Process to their Children's Bureau, Department of Health. Our research center complied by sending an engineer there for 3 weeks to meet with Brazilian officials, present technical details, and develop interest in the process. Since then, UNICEF has distributed six sets of village process machinery for evaluation

to several locations in Brazil, principally child nutrition and education centers. In a rural extension service (ABCAR) project, approved by the UNICEF board at Santiago, a large number of the machines (over 100 sets) were to be sent to Brazil; however, procurement was withheld until a complete evaluation was made of the previous sets provided to Brazil.

Since that time, UNICEF has been supplying sets of machines for the "village process" to various countries.

In 1969, Mr. Yang, FAO Nutrition Officer, stopped at the Northern Regional Research Center in Peoria, Illinois, to report a successful 2-year field service program in Korea. Two sets of village equipment were supplied there in 1968 by UNICEF. His report indicated a very successful village operation there at the pilot village of Kang Wondo, where the process was taught and carried out. Full-fat soy flours of good quality and acceptability were produced. The flours were utilized to make instant dry powder formulations that would be reconstituted with water as porridge, soups, or enriched noodles.

In addition, UNICEF has furnished village equipment to countries such as India, Tanzania, Phillipines, Guatemala, and Mexico. In Tanzania, five sets were provided to the Ministry of Agriculture Training Institute, Morogors, implemented by a food scientist and a food technologist to direct the training program in three African villages. More recently, 30 sets of village equipment were delivered to Northwest Mexico.

FOODS FROM WHOLE SOYBEANS DEVELOPED AT THE UNIVERSITY OF ILLINOIS

The Department of Food Science at the University of Illinois, Urbana-Champaign, Illinois, has also developed procedures for processing whole soybeans into a number of products which could have good potential in developing countries.

The following report which was given by A. I. Nelson and L. K. Ferrier of the University of Illinois at the Workshop on Soybeans for Tropical and Subtropical Conditions, University of Puerto Rico, Mayaguez Campus, February 4-6, 1974, summarizes some of their procedures:

The soybean is an excellent source of nutrients. About 40 percent of the dry matter in the soybean is protein and it also contains about 20 percent fat. The amino acid pattern of soy protein approaches the optimum FAO recommendation and the oil is quite desirable because it contains considerable unsaturated fatty acids. In addition, soybeans appear to be a good source of a number of the required vitamins and minerals. Thus, the soybean has great potential for people who rely mostly upon vegetable sources for protein.

Nearly all of the soybeans produced in the U.S.A. and Brazil are processed in oil extraction plants. The oil is generally needed for mayonnaise, salad dressing, and margarine the world over, and the extracted flake, which contains about 50 percent protein, is used mainly as protein supplement for animal feed. However, human food uses of extracted flake

are increasing rapidly. Some of the products which are processed for human food from extracted flakes include soy protein concentrates, isolated soy protein, textured vegetable protein, and soy protein meat analogs.

Another potential benefit is the direct use of whole soybeans with the oil content intact, for preparing foods for home use and for commercial processing. The Department of Food Science, at the University of Illinois, has developed procedures for processing whole soybeans into a number of products which appear to have real potential. The processing procedure is straightforward and uncomplicated. Basically, all of the processes start with field dried soybeans and foreign material. At this point, the beans are hydrated by soaking in tap water for about 5 to 12 hours followed by precooking (Blanchin) in boiling water for about 20-30 minutes. For products which require tender blanched beans, 0.5% $NaHCO_3$ is added to the blanch water. Products which do not require exceptionally tender beans can be hydrated and blanched in one operation which requires at least 20 minutes. After blanching, the beans are bland in taste and chewy to tender in texture, depending upon the methods followed in rehydration and blanching.

The success of this process is directly related to inactivation of enzymes, principally the lipoxygenase enzyme system in the raw soybean before the tissue is disrupted. When the raw tissue is broken, the

enzyme and the substrate (oil) are liberated and, provided some moisture is present, a bitter, beany taste instantaneously develops. However, the enzyme system is inactivated if the whole soybean is first hydrated and blanched in boiling water. This blanching simultaneously destroys the trypsin inhibitor and hemaglutinins present in raw beans; if present, these inhibitors would substantially reduce the nutritional quality of the soybeans by inhibiting trypsin and other digestive enzymes. The length of time required to destroy these components decreases with increased moisture content of the soybeans. For example, trypsin inhibitors can be destroyed in rehydrated beans (containing 50 to 60 percent moisture) by boiling for 5 minutes. However, if dry soybeans are used, they must be boiled for 20 minutes to destroy trypsin inhibitors. Lipoxygenase is inactivated in rehydrated soybeans by boiling for less than 5 minutes.

Boiling is also essential to produce an acceptable texture and, for practical purposes, the desired texture will dictate the boiling time required. Tenderization is faster at higher pH levels. Use of softened water (pH 7.5) or a 0.5 percent solution of sodium bicarbonate (pH 7.9) results in much more rapid tenderization and sharply reduces required cooking time. Soaking and boiling also removes about one-third of the oligosaccharide in soybeans, some of which are believed responsible for the production of flatus. Only a small amount of the protein (1 percent of the Kjeldahl nitrogen) is lost during soaking and blanching.

As mentioned earlier, when the tissue of the soybean cotyledon is disrupted or damaged and moisture is present, the characteristic "beany" or "painty" off-flavor develops. In University of Illinois tests, drum dried products were prepared using 0, 25, 50, 75, and 100 percent slightly damaged soybeans. Taste panels could easily detect the beany off-flavor when 25 percent slightly damaged soybeans were processed by the Illinois process, although the flavor difference was not pronounced. If hull damage is greater than 15 to 20 percent, blanching before soaking is recommended.

Properly hydrated and blanched soybeans offer great potential for processing into a wide variety of food products. Some of the foods which were made at the University of Illinois are listed in Table 1. Each category will be discussed briefly.

Category I. Drum Dried Flakes

1. 100% Whole Soybean
2. Soy-Rice (50:50)
3. Soy-Corn (50:50)
4. Soy-Brown Sugar-Peanut (50:35:15)
5. SoyBanana (50:50) Weaning Food

Category II. Canned and Homecooked Soybeans

1. Vegetarian soybean
2. Three bean salad
3. Soy with chicken
4. Soy with pork
5. Soy with lamb
6. Pork with soybeans

Category III. Soy Beverages and Beverage Products

1. Beverage, plain
2. Beverage, chocolate flavored
3. Blend of soy beverage and cottage cheese whey
4. Ice cream, mocha flavor
5. Yogurt

Category IV. Spreads

1. Diet spread, margarine flavor
2. Dip
3. Peanut butter analog

Category V. Snacks

1. Roasted soybean cotyledons
2. Extruded, puffed rice and corn fortified with full-fat soy flour

Category I. Drum Dried Flakes

The drum dried flakes are made by preparing a slurry of the cooked soybrans in water and drum drying the slurry. If the final product contains other materials such as fruit or cereals these are mixed in the soybean slurry and the combination is drum dried. These flakes may be used directly as a weaning food or they may be mixed into other foods such as baked goods to increase the protein content. Mixtures of soybeans and cereals such as corn or rice should improve the essential amino acid profile since cereals are typically low in lysine and adequate in methionine whereas legumes, such as soybeans, are normally the reverse, that is, low in methionine and adequate in lysine.

Soybean-fruit mixtures have potential because the flavor of the fruit is dominant in the dried flakes but the increased protein and calorie content of the soybean is present. A 1:1 soybean:banana flake was prepared as described earlier. The best product resulted when very ripe bananas were used. This product is very stable and contains a good mixture of the major nutrients, -viz 23% protein, 9% oil, and 50% carbohydrate. This product was found to be low in methionine but the deficiency can be corrected by addition of methionine or by adding corn to the formula as mentioned in the earlier workshop paper by Dr. Bressani. This product should provide a tasty nutritious weaning food as is. This also provides a useful method for using very ripe bananas which would otherwise be discarded.

Category II. Canned and Homecooked Soybeans

The concept for hydration and blanching of whole soybeans offers potential for home utilization of whole soybeans. Recipes for preparation of soybeans for home use have been developed and are available from a number of countries, for example, that by Dr. Van Duyne in the Department of Home Economics at the University of Illinois. We believe that the principles involved in hydration and blanching would improve some foods in which the recipes call for procedures that allow some enzyme activity before blanching or cooking.

We have made use of a number of recipes to prepare canned soybeans having a variety of flavors (Table 1). Standard bean processing procedures were used to can these products except that the soybeans were presoaked in weak $NaHCO_3$ solution rather than tap water.

Category III. Soy Beverages and Beverage Products

A simple process was developed at the University of Illinois which allows use of blanched soybeans to produce a stable soy milk no beany flavor. The whole soybean is used and the soy milk contains as much as 3.6 percent protein (depending on dilution), equivalent to that in cow's milk and nearly twice as much as the soy milk currently marketed or manufactured by the traditional process. Essentially 100 percent of the protein and 95 percent of other constituents are recovered from the bean. The only losses occur during blanching and these losses are desirable with respect to reducing flatus. Basically the beverages are prepared by grinding the cooked soybeans with water, adding sucrose and flavoring, homogenizing and pasteurizing.

The major disadvantage is the necessity of homogenization in order to produce a stable suspension. Thus, it is not a home or village scale process. The major advantages compared to the traditional soy milk are an excellent mild flavor, no off-flavor, destruction of antinutritional factors and increased protein content. A University of Illinois patent application covers the preparation of the soybean beverage base. The beverage has been used to replace milk in products such as, soy ice cream soy yogurt custard, and diet margarine, all of which are prepared by conventional methods.

Category IV. Spreads

Spreads of intermediate moisture foods constitute another group. An excellent diet margarine was prepared following conventional methods but using soy beverage instead of milk solids. A very acceptable chip dip can be prepared simply by changing the flavorings used. Roasted soybean cotyledons plus added soybean oil can be processed using a colloid mill into a "soybean butter" which resembles peanut butter in character and flavor.

Category V. Snacks

Soybeans can be roasted to make a dry nut similar to peanuts. First the blanched soybeans should be dehulled using a disc (Buhr) mill or similar mill. At home dehulling can be done by rubbing small handfulls between the hands. Rinse with water to remove the hulls and fines. After draining, the cotyledons are deep fried in oil at about 190°C for 2-1/2 minutes. They may be roasted at home in a frying pan with a little oil but the roasting time will be longer. If the hulls are left on, the roasting time is longer. Salt or other flavorings should be added while the beans are still hot.

Extruded puffed snack foods have also been prepared using a Wenger extruder. The feed flour contains about 20 percent full fat soy flour and 80 percent corn or rice flour. After addition of oil and flavoring (as is usually done to this type of snack), the protein content is at least 3 g./100 calories.

We believe that tasty snacks provide an avenue for introducing soy food to people who would normally resist trying any unfamiliar food.

These few examples illustrate the wide variety of tasty and nutritious foods which can be manufactured from a single starting material--the cooked, whole soybean. We believe that those and other soybean products can be adapted to fit the taste and texture preferences of people throughout the world.

WAYS OF COOKING AND SERVING SOYBEANS IN THE AMERICAN DIET

WAYS OF COOKING AND SERVING SOYBEANS IN THE AMERICAN DIET

Until a few years ago, the closest that any Westerners got to soybeans was an occasional dash of soysauce. In recent years, soybeans have gained prominent recognition as human food because of their high protein content, their richness in unsaturated oil, and their abundance. Soybean flour and textured soy protein are now widely used in bakery goods and meat-flavored products that are available in most markets. The use of whole soybeans, on the other hand, is still limited.

One of the factors that affects the use of whole soybeans for food is the lack of knowledge of how green soybeans and dry soybeans can be properly prepared for consumption. Smith (1973) found that dry soybeans can be used in casseroles, soup, salad--anywhere one would use navy or kidney beans. She developed many excellent recipes and claimed they are so good, so versatile, and so satisfying that one can easily eat them once a week without feeling or being martyred. Two other publications, one from the College of Agriculture Cooperative Extension Service, University of Illinois, and the other from USDA also are devoted entirely to soybean cooking for this country.

In these publications, instructions are given on boiling soybeans. They are basically the same: soaking the beans overnight, cooking with the addition of salt, or chopped onion, bay leaf, and pepper for more flavor, and simmering for 1-3 hr. They also suggested to reserve the

soaking water for cooking. However, laboratory results and the Oriental experience have shown that soaking processes remove some undesirable factor. Therefore, one should discard the soaking water.

Many simple and good recipes are given in these publications; therefore, they are attached in the appendices. The Protein for Pennies cookbook by John Woods is also a soybean cookbook and contains over 200 soybean recipes. The Farm Vegetarian Cookbook by the Farm provides many simple ways of preparing and serving soybean foods. Undoubtedly, there are other publications concerning soybean cooking.

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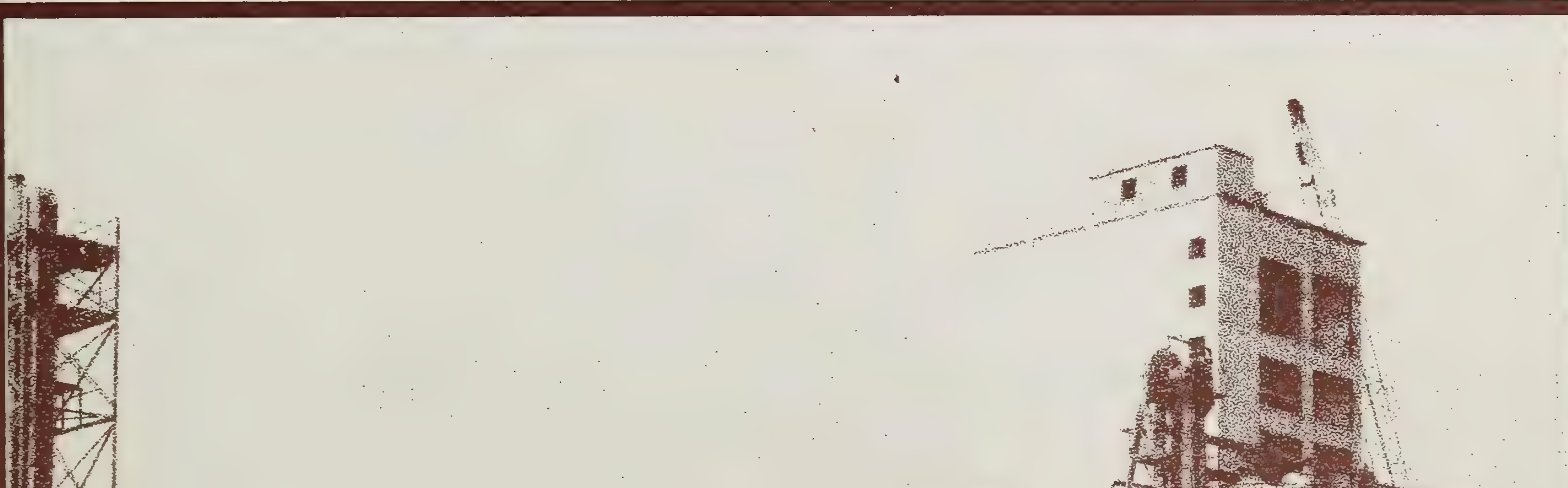
INDUSTRIAL PROCESSES

Edible Soy Protein

Operational Aspects of Producing and Marketing



Farmer Cooperative Service
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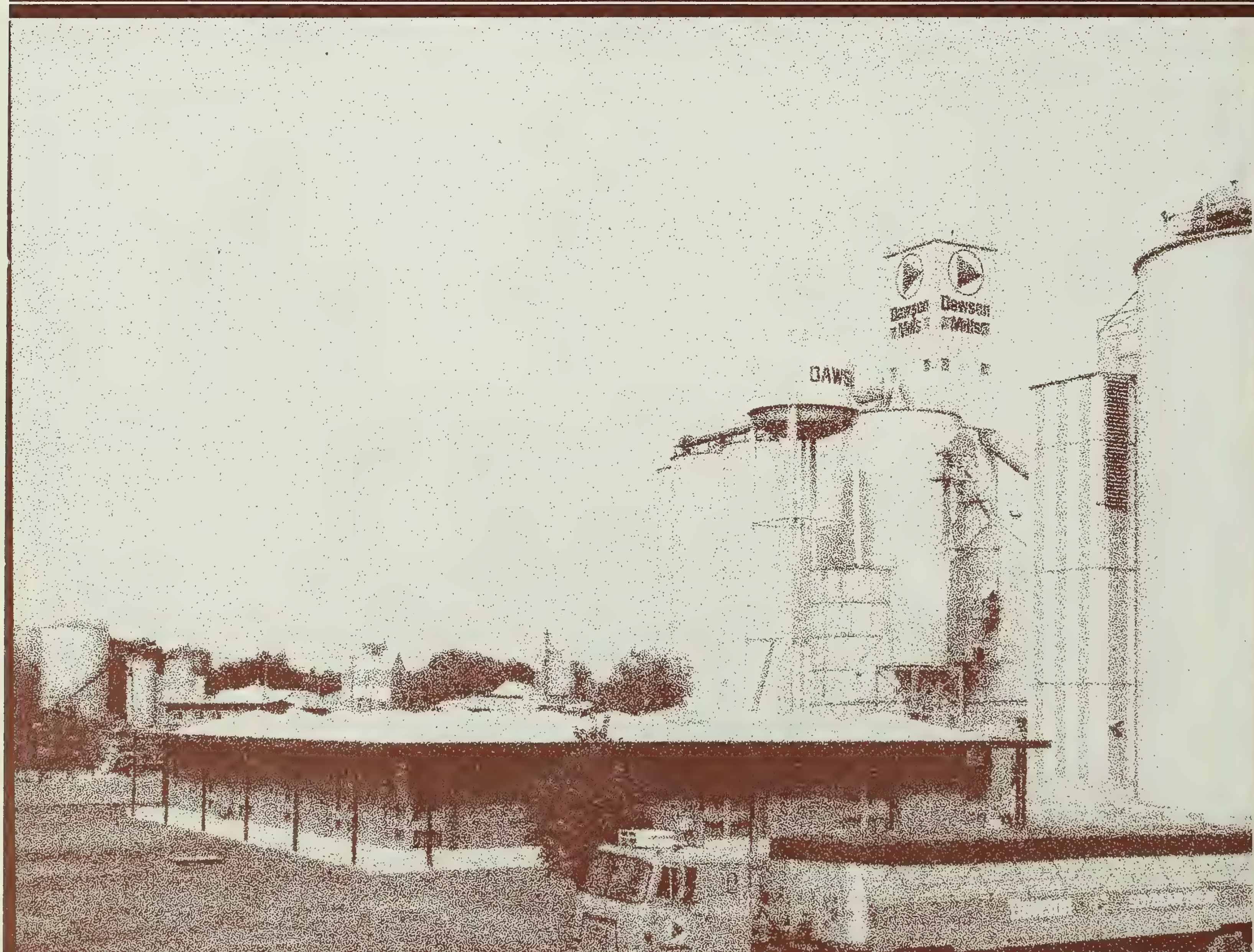
FCS Research Report 33



The Dawson Mills soybean processing complex, located at Dawson, Minn., is highlighted above and in the cover photograph. Part of the extractor plant and edible soy plant are shown on the cover, while offices and storage facilities are pictured above.

PREFACE

Faced with the question of whether or not to start producing and marketing edible soy protein, several soybean processing cooperatives turned to Farmer Cooperative Service (FCS) for help. Essentially, they each wanted FCS to marshal and analyze the facts. Because the requests were similar, FCS concluded that the prudent approach would be to gather the available facts and prepare a report that would be made available to anyone who wanted it.

Contacts with Government agencies bore fruit. Because they are public institutions, they were willing to share information they have developed. The principal and most valuable source of information was the Northern Regional Research Laboratory (NRRL) at Peoria, Ill. NRRL is a part of the Agricultural Research Service (ARS), U.S. Department of Agriculture (USDA). The Economic Research Service (ERS) and Food and Nutrition Service (FNS), USDA, also provided information. Information on current good manufacturing practices came from the Food and Drug Administration (FDA), Department of Health, Education, and Welfare (HEW).

Some technical, operational, and economic information was held by private companies. Because they had invested substantial resources to develop these kinds of information and to capture a share of the market for themselves, they were understandably reluctant to release such information for publication.

To assure proper credit for the individuals contributing to this report, the author of a particular section is identified in that section. Those sections that do not have a specific author identified were prepared by Bert D. Miner, FCS.

The contents are grouped under seven major headings. After a brief introduction, the different kinds of soy products, their uses and production and outlets are described. Processes, equipment, capital and processing costs are then treated. Because soy products are being prepared for human consumption, a section is included on current good manufacturing practice. Market growth and market potential are examined next. An appendix section of companies producing and distributing soy products is included for reference.

The use of firm and equipment names is for identification only and not intended as an endorsement by the U.S. Department of Agriculture.

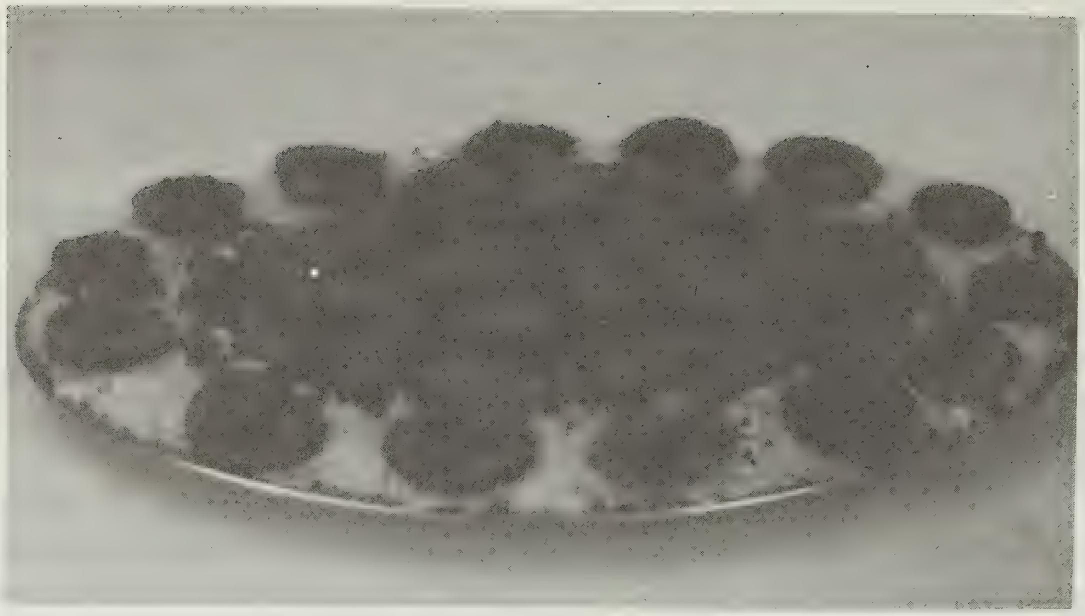
Citations in parentheses in sections refer to literature cited lists at the end of the section.

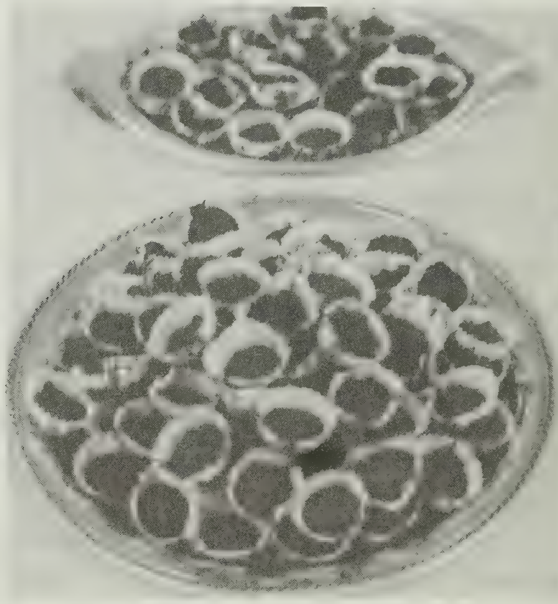
FCS Research Report 33 January 1976

CONTENTS

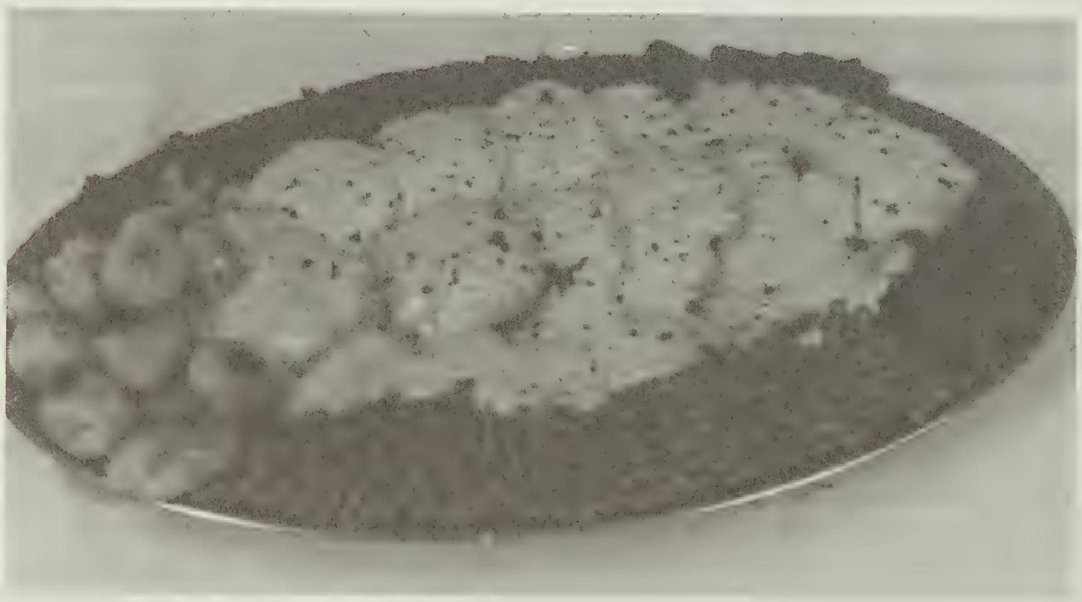
HIGHLIGHTS

- The three principal classifications of edible soybean proteins are flours and grits, concentrates, and isolates. These are based upon percentage of protein content—40–50, 70, and 90–95. From these, textured protein products are made.
- Heat-treatment of defatted soybean flakes needs to be very carefully controlled because of its effect on protein color, flavor, and functional properties—fat and water absorption and solubility.
- Soy protein is added to other foods to provide functional properties and to supply dietary protein. These two important uses make soy proteins acceptable for use in a broad variety of foods.
- The fastest growing segment of the edible soy protein business has been textured items, mainly of the extruded flour type. It is also the most competitive.
- Economic processes and efficient equipment are presently available to produce edible soy protein.
- Assuring a high standard of sanitation in any plant producing edible soy protein is absolutely essential. Construction of a plant to produce edible soy protein must include provisions for effluent disposition in harmony with Environmental Protection Agency (EPA) standards.
- The relative cost of soy proteins, compared with that of animal proteins, indicates that soy proteins will continue to expand present markets and penetrate new markets. Development of additional desired qualities in soy proteins will speed their market expansion and penetration.
- The largest and fastest growing market for soy protein is expected to be in meat extenders and meat analogs.
- Government regulations are expected to be modified to favor additional uses and quantities of soy protein in foods.
- Institutions are the major market for soy protein products and are expected to continue to be for some time. The School Lunch Program is by far the largest institutional market.
- Large quantities of soy protein are expected to be used in foreign feeding programs, particularly those conducted under P.L. 480.





Display of edible soy protein products



EDIBLE SOY PROTEIN:

Operational Aspects of Producing and Marketing

Bert D. Miner
Farmer Cooperative Service

INTRODUCTION

During the past 30 years, the soybean has sprung from relative obscurity to stardom. The principal role that has brought about such world acclaim is the meal that has provided a major source of protein supplement for animal feed. It has been more recent that soybean oil has begun to demonstrate an important independent role. Edible soy protein is still waiting for its big chance.

We hear and read much about the awesome need for protein to feed the multitude of hungry people around the world. We also hear and read much about the alleged inefficiency of producing animal protein as opposed to producing vegetable protein, particularly soy protein. Yet despite the obvious human need, we are still confronted by the complex economics of production, distribution, and consumption when we make business decisions. In other words, need is not economic demand. Demand is need or desire coupled with purchasing power. Economic enterprises produce to satisfy demand rather than need. The broad economic aspects of this complex problem are far beyond the scope of this report. This report is limited to setting forth some of the economic and operational aspects of producing and marketing edible soy protein. We expect that the contents will provide a substantive basis upon which to make a decision of whether or not to initiate production of edible soy protein.

Food scientist, Kris Olson, prepares taste samples in Dawson Mills test kitchen.

KINDS OF SOY PRODUCTS

W. J. Wolf
Northern Regional Research Laboratory

Edible soybean proteins are classified according to protein content:

Products	*Protein content* *Percent*
Flours and grits	40–50
Concentrates	70
Isolates	90–95

Figure 1 shows the proximate compositions and yields of these protein forms in relation to soybeans.

Initial applications of soybean proteins in foods were at low levels to provide desirable functional properties such as emulsification, water absorption, and texture. As animal proteins have risen in price, soy proteins have become more valuable as dietary protein sources, because they provide functional properties. The best example of food products utilizing soybean proteins for nutritional purposes are the textured soybean proteins now used as meat extenders and meat analogs. These are made by further processing of flours and grits, concentrates, and isolates. Each of these three basic protein forms will be described as well as their conversion into textured products.

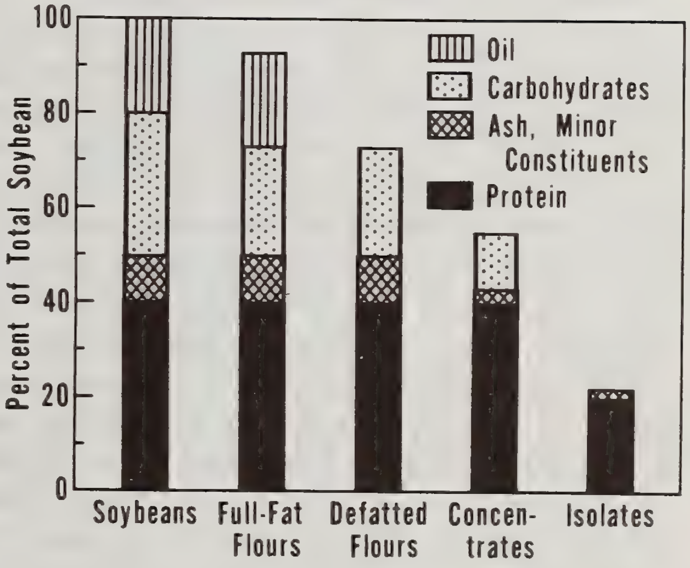


Figure 1.—Proximate compositions (dry basis) and yields of the major protein forms obtained from soybeans.

Effect of Moist Heat on Soybean Proteins

Before describing the various protein forms in more detail, it is necessary to understand the effects of moist heat on the properties of the proteins. Moist heat treatment (commonly called toasting) is used in the production of a number of soybean products when there is need to inactivate enzymes, such as lipoxygenase, which can reduce storage stability or to destroy antinutritional factors, such as trypsin inhibitor.

Proteins in soybean flakes and flours that have been processed with little or no moist heat treatment are easily extracted with water. If the flakes are steamed, however, the proteins are denatured and are no longer soluble in water. Denaturation is a complex change that occurs in many proteins when they are treated with moist heat or with aqueous alcohol. One of the most common changes noted when proteins are denatured is a loss of solubility in aqueous solutions (for example, coagulation of egg white in a boiled egg). Figure 2 shows that protein solubility of soybean flakes (measured as Kjeldahl nitrogen in a water extract of flakes) drops very rapidly from its initial high value to 20 to 25 percent after steaming for only 10 minutes at atmospheric pressure. The presence or absence of oil in the flakes has no significant effect on the rate of protein insolubilization. Three factors—time, temperature, and moisture content—are critical in controlling rate of soybean protein denaturation (Becker, 1971). Because denaturation causes insolubilization of soybean proteins, solubility measurements are used to determine the extent of heat treatment given to flakes, flours, and grits.

Two empirical methods are commonly employed to measure the degree of protein denaturation in soybean flours and grits: nitrogen solubility index (NSI) and protein dispersibility index (PDI). In both procedures, the sample is stirred with water under specified conditions and centrifuged; the resulting supernatant is then analyzed for Kjeldahl nitrogen (American Oil Chemists' Society, 1973). For some other commodities, such as cottonseed flour, conditions for protein solubility determination are further modified by use of alkali instead of water. NSI and PDI values are the percent of total nitrogen in the sample that is soluble, although PDI is expressed as a percent of protein (N X 6.25).

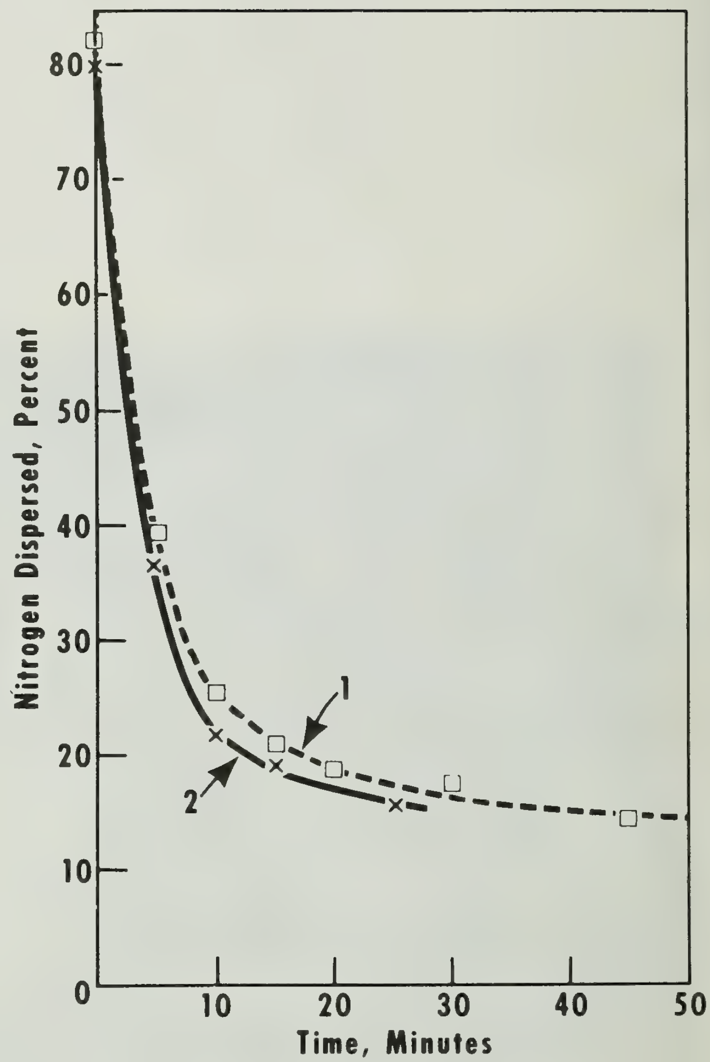


Figure 2.—Effect of steaming time at atmospheric pressure on water dispersibility of nitrogenous constituents of (1) defatted flakes and (2) full-fat flakes. From Belter and Smith (1952).

The two methods do not give identical values for a given sample because their extraction conditions differ. The NSI procedure uses slow stirring during the extraction step, whereas the PDI method employs fast stirring with a modified blender that chops the sample during extraction. A plot of PDI versus NSI (fig. 3) shows that PDI values are higher than NSI for a given series of samples. Figure

3 shows that after NSI and PDI reach minimal values, they will no longer indicate the extent of heat treatment; NSI and PDI values are not valid indicators of overcooking.

Another test frequently used to assess degree of heat treatment given to soy flours and grits is urease activity (American Oil Chemists' Society, 1970). The soybean sample is incubated with a buffered solution of urea. If the enzyme urease is active, it hydrolyzes urea to release ammonia, which in turn causes an increase in pH of the incubation mixture. Increase in pH is used as a measure of urease activity, but the test is applicable only to samples that have had moderate to full cooking. The relationship between pH increase and urease activity is not linear over the entire range from raw to fully cooked.

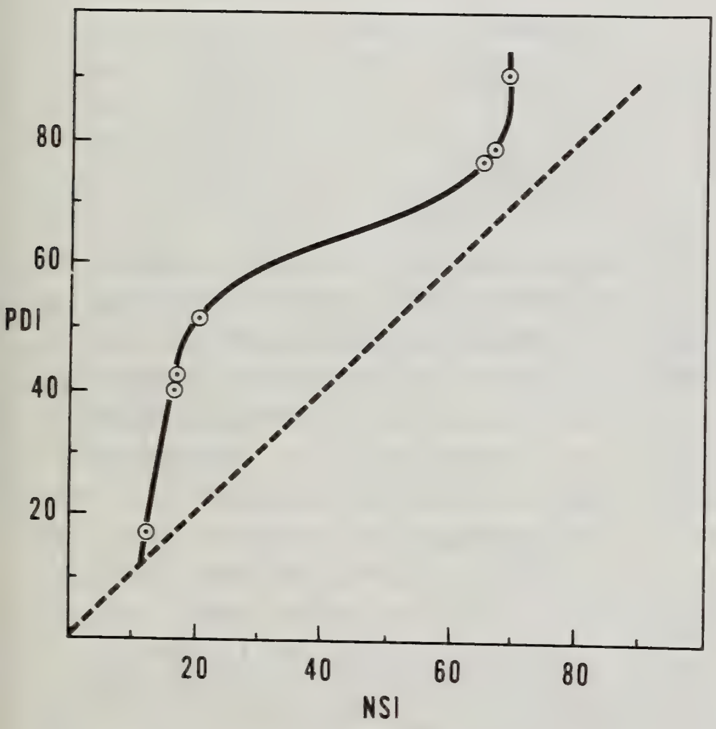


Figure 3.—Plot of nitrogen solubility index versus protein dispersibility index for a series of heated samples. The dashed line is the curve expected if the two values are identical. Adapted from Horan (1974A).

Raw soybeans contain antinutritional factors, such as trypsin inhibitors, that cause poor growth when they are fed to animals (Smith and Circle, 1972). The antinutritional factors are readily inactivated by moist heat treatment; consequently, all defatted meal used for feeds is thoroughly cooked or toasted. For food uses, however, it is often unnecessary or undesirable to completely cook soybean protein products before incorporating them into food items. Additional processing by the food manufacturer is relied upon to adequately heat-treat the proteins. In addition to improving nutritional value and decreasing protein solubility, heat treatment also affects flavor, color, and functional properties such as fat and water absorption.

Flours and Grits

Edible soy flours and grits are made from dehulled beans and are classified according to particle size:

Product	*Mesh size**
Grits:	
Coarse	10–20
Medium	20–50
Fine	50–80
Flours	100 or finer

* U.S. standard screen

Grits are prepared by coarse grinding and screening, compared with flours that are ground until 97 percent of the material passes through a 100-mesh screen. Many soy flours are ground to 200-mesh size and specialty flours of 300-mesh size are also available. The term flour as applied to soy refers only to particle size; no similarity to wheat flour is intended.

In addition to varying in particle size, available flours and grits also differ in fat content. Standards for soy flours used in the trade are given in table 1. Typical analyses for these products plus lecithinated grits and flours are shown in table 2.

Full-Fat Products.—In commercial preparation of full-fat flours and grits, the beans are cleaned, cooked, dried, cracked, dehulled, ground, and screened (Pringle, 1974). Altern-

Table 1—Soy flour standards[1]

Constituent	Full-fat soy flour	Low-fat soy flour	Defatted soy flour
		Percent	
Protein (N X 6.25)[2]	40.0 min.	45.0 min.	50.0 min.
Protein (N X 5.7)[2]	36.5 min.	41.0 min.	45.0 min.
Fat (ether extract)[2]	18.0 min.	4.5 min.—9.0 max.	2.0 max.
Fiber[2]	3.0 max.	3.3 max.	3.5 max.
Moisture	8.0 max.	8.0 max.	8.0 max.
Ash[2]	5.5 max.	6.5 max.	6.5 max.

[1] From Soybean Digest Blue Book Issue (1974). 97 percent will pass through a No. 100 U.S. standard screen for each of the above.
[2] Moisture-free basis.

Table 2—Proximate analyses of flours and grits[1]

Constituent	Flour or grit			
	Full fat	Low fat	Defatted	Lecithinated
		Percent		
Moisture	5.0	5.5	5.0	5.5
Protein (N X 6.25)	41.5	46.0	53.0	45.2
Fat	21.0	6.5	0.9	16.4
Crude fiber	2.1	3.0	2.9	2.4
Ash	5.2	5.5	6.0	5.3

[1] As-is basis. Analyses are not product standards but are typical for products (Meyer, 1970).

tively, the beans may be cracked and dehulled before heating (Horan, 1974A). Full-fat flours are the least refined commercial soybean protein products, because only the hulls are removed. Hulls consist mainly of indigestible carbohydrates cellulose and hemicelluloses. Cooking is used to inactivate enzymes, such as lipoxygenase that, if permitted to remain active, are believed to catalyze oxidation of linoleic and linolenic acids in the oil and in turn lead to development of off-flavors (Mustakas and others, 1969; Nelson and others, 1971). Commercial full-fat flour has a PDI value of 35 to 45, which reflects the initial cooking step. A pilot process for preparing full-fat flour by extrusion cooking has recently been developed (Mustakas and others, 1970). This process is being used in a number of installations overseas, and is described in detail in the section, Soy Processes, Equipment, Capital, and Processing Costs.

Defatted Products.—Defatted flours and grits are made by the following sequence of steps: cleaning, cracking, dehulling, conditioning, flaking, extracting, desolventizing, grinding, and screening. The oil as well as the seedcoat is removed during this processing. The oil is extracted with hexane, and as a result, defatted grits and flours contain a minimum of 50 percent protein, but typically will analyze higher (table 2). Defatted grits and flours are the major soybean protein form produced at present and are also the starting materials for further processing into protein concentrates and isolates.

To provide food ingredients with a wide variety of properties, defatted flours and grits are available with a range of moist heat treatments. Smith and Circle (1972) give the following classification of flours and grits according to the extent of heat treatment and NSI values:

Amount of heat	*NSI*
Minimum	85–90
Light	40–60
Moderate	20–40
Fully toasted	10–20

The critical step in preparation of defatted flours and grits with varying heat treatments is desolventizing. Flakes coming from the extractor contain about 30 percent hexane; in conventional processing for feeds, hexane is removed and recovered in a desolventizer-toaster that uses steam to evaporate the hexane for recovery and to cook or toast the flakes. For edible purposes, less than complete cooking is often desired; hence, other methods are employed for desolventizing (table 3).

The Schneckens system is the oldest method now used and provides flours and grits with PDI values that lie between a raw and a fully cooked product. If an undenatured flake is desired for conversion into one form (isoelectric washed) of protein concentrate or protein isolate, then either the flash desolventizer-deodorizer or vapor desolventizer-deodorizer can be used. If steam sparge used in the deodorization step of the vapor desolventizer-deodorizer is done under vacuum, one obtains a flake with a high PDI. But if the deodorization is carried out under 1 to 2 atmospheres

Table 3—Processes used to desolventize soybean flakes for edible products

Process	Method of hexane vaporization	PDI range of flakes [1]
Schneckens	Steam jacketed conveyor with steam sparge [2]	40-50
Flash desolventizer-deodorizer	Superheated hexane followed by inert purge gas	70-90 [3]
Vapor desolventizer-deodorizer	Superheated hexane followed by steam sparge under vacuum or pressure	10-90

[1] Becker, 1971. PDI = protein dispersibility index.
[2] Newer versions of this system use hollow-screw conveyers with heat transfer agents circulating through them to increase heat transfer efficiency.
[3] When flakes with lower PDI values are desired, the flash desolventizer is followed by a meal stripping and cooking operation (Milligan and Suriano, 1974).

of pressure, the steam condenses and the PDI value goes down. Flakes spanning the entire range of PDI values can therefore be prepared by controlling conditions during deodorization.

Defatted flours and grits can also serve as the starting material for low-fat and lecithinated products. These items are usually made by adding back the desired level of oil or lecithin to defatted materials; small quantities of low-fat flours and grits are made by expeller processing to reduce the oil content of dehulled beans to 6 percent.

Protein Concentrates

Concentrates are made from defatted flours or grits by removing soluble sugars (sucrose, raffinose, and stachyose), along with some ash and minor constituents, as shown in figure 4. Sugars make up about one-half of total carbohydrates of defatted flours; the other half consists of indigestible polysaccharides that make up the cell walls in soybeans. Sugars are removed by extracting with: (1) aqueous alcohol (Mustakas and others, 1962); (2) dilute aqueous acid (Sair, 1959); or (3) water, after first insolubilizing the proteins by moist heating (McAnelly, 1964). All these processes are patented, although the alcohol extraction process patent is assigned to the U.S. Government (Mustakas and Griffin, 1966) and is available for licensing on a nonexclusive, royalty-free basis. In all three extraction processes, proteins and polysaccharides remain insoluble and are recovered in the final product.

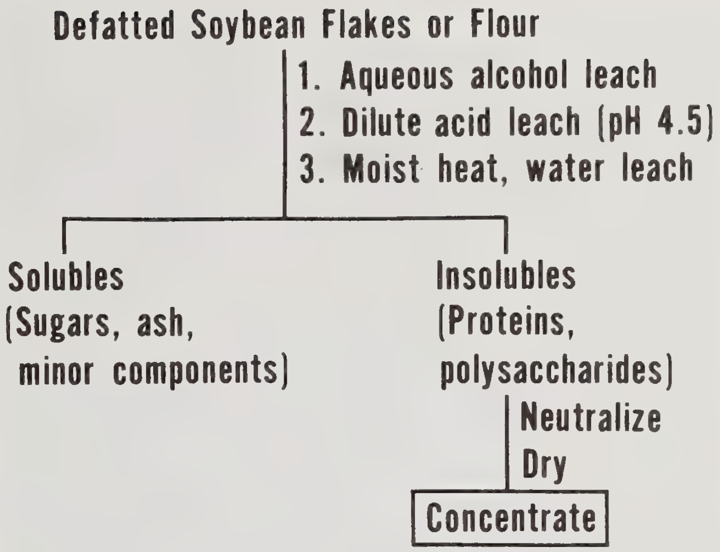


Figure 4.—Processes for preparing soybean protein concentrates. Extraction of sugars is made by one of three alternate methods as described in the text.

Table 4 gives proximate analyses of three commercially available protein concentrates. Chemical compositions are quite similar for the three concentrate types, but a major dif-

Table 4—Proximate analyses of soy protein concentrates [1]

Property or constituent	Manufacturing process		
	Alcohol leach	Acid leach	Moist-heat, water-leach
NSI [2]	5	69	3
pH of 1:10 water dispersion	6.9	6.6	6.9
		Percent	
Protein (N X 6.25)	66	67	70
Moisture	6.7	5.2	3.1
Fat (petroleum ether extractable)	0.3	0.3	1.2
Crude fiber	3.5	3.4	4.4
Ash	5.6	4.8	3.7

[1] As-is basis. From Meyer (1970).
[2] NSI = nitrogen solubility index.

ference exists in the physical properties. The concentrates made by the alcohol leach and moist-heat, water-leach processes have very low NSI values. In the first process, aqueous alcohol and heat cause protein denaturation, whereas in the second process, steam treatment insolubilizes the proteins.

Protein Isolates

Isolates are the most refined form of soybean proteins available commercially. By definition, they must contain a minimum of 90 percent protein (N X 6.25) but often analyze 95 percent or better. Like concentrates, isolates are made from defatted flakes or flours, but the starting material must have a high NSI or PDI value to ensure economical yields of protein. The isolation process is summarized in figure 5. Defatted flakes are extracted with water plus sufficient alkali to adjust the pH to 7 to 9. Spent flakes, which contain the water-insoluble polysaccharides plus some residual protein, are then separated by filtration or centrifugation. The clarified extract, containing most of the proteins plus sugars, is acidified to about pH 4.5. This step adjusts the proteins to their isoelectric point and causes them to coagulate so that they can be separated by centrifugation or filtration. The supernatant or filtrate (also referred to as soybean whey) contains sugars, ash, and minor constituents. Next, the protein curd is washed,

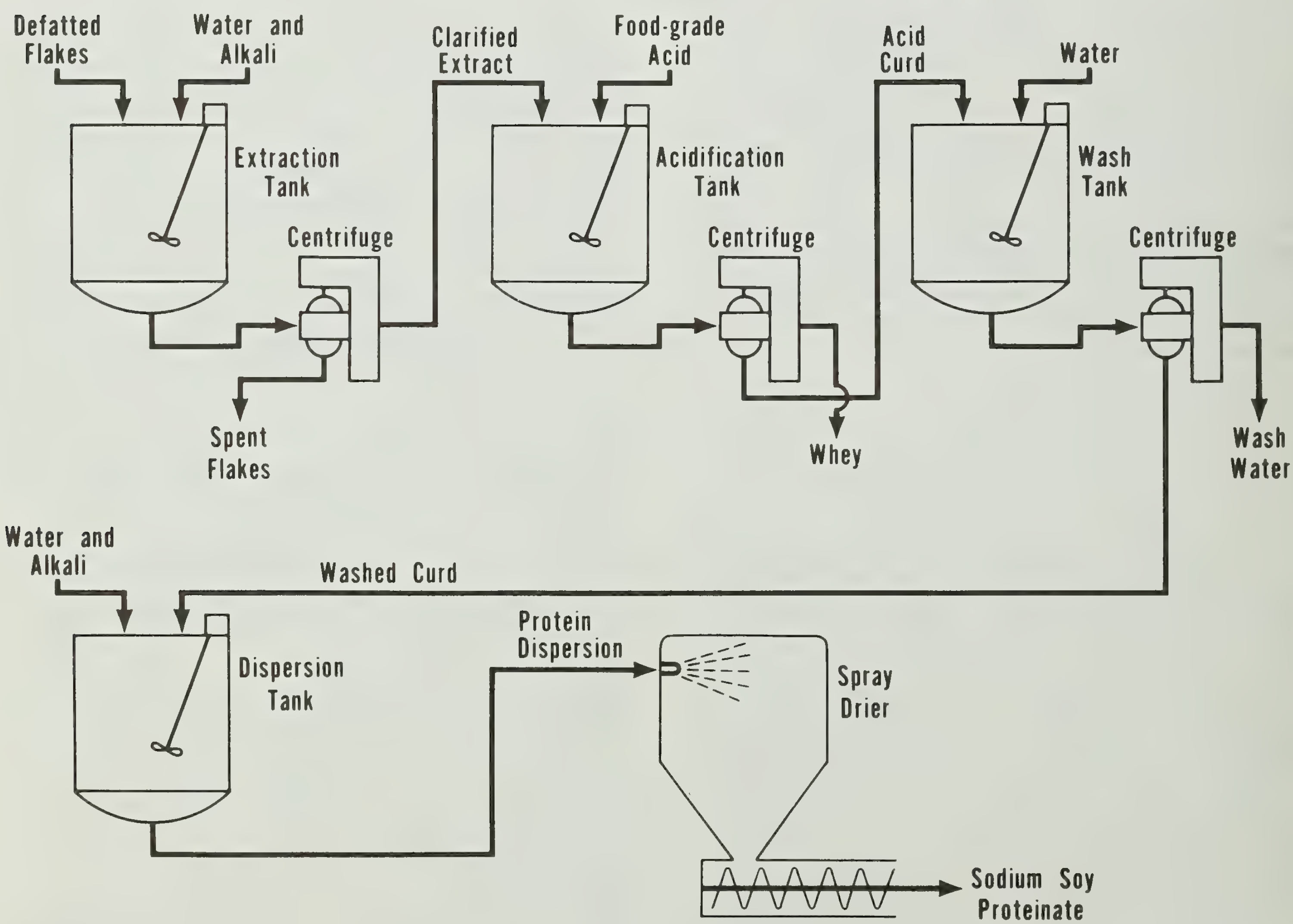


Figure 5.—Process for production of soybean protein isolates.

slurried in water, and spray-dried to give the isoelectric protein. More commonly, however, the protein is neutralized with alkali and then spray-dried to yield the sodium proteinate form. Table 5 gives proximate analyses for four commercial samples of isolates. Samples A and B were neutralized before drying, whereas samples C and D were left in the acidified condition. The proteinate samples have high NSI values, whereas the isoelectric samples are insoluble in water.

Table 5—Proximate analyses for four commercial soy-protein isolates[1]

Property or constituent	A	B	C	D
NSI[2]	85	95	---	---
pH of 1:10 water dispersion	7.1	6.8	5.2	5.5
		Percent		
Protein (N X 6.25)	92.8	92.2	92.9	94.7
Moisture	4.7	6.4	7.6	3.7
Crude fiber	0.2	0.1	0.1	0.2
Ash	3.8	3.5	2.0	2.7

[1] As-is basis. From Meyer (1970).
[2] NSI = nitrogen solubility index.

Small amounts of protein isolates (estimated to be less than a million pounds in 1967; Eley, 1968) are treated with the proteolytic enzyme pepsin to partially hydrolyze the protein for use as a whipping agent in the confectionery and bakery trades. These products are often referred to as modified or enzyme-modified isolates.

Textured Soybean Protein Products

Further processing of the basic forms—flours and grits, concentrates, and isolates—is now practiced to give soybean proteins a texture that resembles specific types of meat; these items range from extenders to be used with ground meats to complete meat analogs. The textured protein products are of two general categories: (1) extruded soy flours and (2) spun protein isolates. However, this distinction is being blurred by new products. One consists of a mixture of soy flour, protein concentrate, and protein isolate, although soy flour is the major ingredient. Another product contains soy protein concentrate, spun soy isolate, and isolated soy protein in order of decreasing proportions. U.S. patent literature on textured products for 1960 to 1972 was summarized by Gutcho (1973), and a detailed review of meat analogs appeared recently (Horan, 1974B).

Extruded Soy Flours.—Extruded flours are made by mixing defatted soy flour with water plus flavors, colors, and supplementary nutrients, if desired, and then passing the mixture through a cooker-extruder. Elevated pressure and temperature in the extruder convert the wet flour into a plastic mass that is extruded through a die. The pressure and temperature drop that occur on extrusion cause expansion and a fibrous structure. The expanded product is then dried to about 8 percent moisture. The extrusion process gives the soy flour a chewy texture when it is hydrated. This is the major type of textured product currently available, and about a dozen companies now make these materials (see Table 8, Production Estimates and Market Outlets). The process is patented (Atkinson, 1970) and licensing is required.

Another process for texturizing soy flour was described more recently by Strommer (1973). Soy flour is introduced into a multi-chambered rotary valve, and as the valve turns, the soy flour is subjected to high-pressure steam and ejected through a nozzle into a zone of low pressure. The sudden pressure drop causes a texturizing and flashes off volatile compounds that contribute undesirable flavors in soy flour. In contrast to the extrusion process, this treatment involves no mechanical working of the soy flour except for the instant during ejection through the outlet nozzle. In the examples cited by Strommer, blends of soy flour, protein cencentrates, and protein isolates were texturized.

Composition of textured soy flours is essentially the same as that of defatted flours and grits—that is, about 50 percent protein. Flavors, colors, and supplements of vitamins and minerals, when added, do not change overall composition significantly. Advantages of textured soy flours over spun protein isolates include: (1) ease of manufacture; (2) low cost; and (3) long storage life. The bacterial count for these products is low and under normal storage conditions they can keep for at least a year. They are, however, limited in their applications because they do not have the high degree of meat-like texture characteristic of the spun fiber products.

Spun Protein Isolates.—The basic process for spinning soy protein isolates into meat-like fibers was first described in a patent issued to Boyer (1954). The basic patent has expired but companies now engaged in this business hold patents on improved versions of the original invention and on methods for converting the fibers into meat analogs (Hartman, 1967; Tombs, 1972; Westeen and Kuramoto, 1964).

Spinning is a complex operation involving a highly sophisticated technology and requires large capital investments (Thulin and Kuramoto, 1967). Protein isolate is dispersed in alkaline solution, which is then filtered and forced through a spinnerette (a metal plate, usually platinum, with up to 15,000 holes about 0.003 inch in diameter) into an acid-salt bath that coagulates the streamlets of protein solution as they emerge to form fibers. Bundles of fibers or "tows" are then drawn from the coagulating bath with power-driven rolls to stretch and toughen them. The stretched fibers are then passed through a washing bath to remove the acid-salt coagulant, followed by immersion in a vat containing a binder (such as egg albumin). After impregnating the tow with binder, it is heated to set the binder and to cement the fibers together. Next, fat, flavors, colors, and nutrients—such as vitamins—can be added. After appropriate shaping, cutting, and drying, a variety of analogs of ham, beef, chicken, and seafood can be prepared.

Composition of the final products made from spun fibers will vary, but a typical composition is given in table 6. Some analogs such as fried bacon-like bits are low enough in moisture to keep at room temperature, but many contain 50 percent moisture or higher and are sold frozen in a ready-to-eat form. Storage of these products is therefore more expensive than that for textured flours. The spun fiber products, however, have the advantages of being more meat-like in texture and providing flexibility in composition of the end product. Because of the complex processing required, including the use of protein isolate, spun fiber products are more expensive than textured flours.

Table 6—Composition of spun protein isolate products [1]

Component	Percent
Spun fiber	40
Protein binder	10
Fat	20
Flavors, colors, and supplemental nutrients	30

[1] Dry basis. From Thulin and Kuramoto (1967).

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PRODUCT USES

W. J. Wolf
Northern Regional Research Laboratory

The various soy protein products now available are added to a large number of food items for two reasons: (1) to provide functional properties and (2) to supply dietary protein.

Functional Properties

A functional property is one that imparts desirable changes to a food during processing or in the finished product. Examples of functional properties are water absorption, viscosity, emulsification, fat absorption, and texture. In many applications, the functional effects are obtained with only a few percent of soy protein; hence, the contribution to dietary protein may be minor.

A given functional property does not always ensure use of soy protein in certain foods. For example, when isolates are washed with aqueous alcohols, their solutions can be whipped to form very stable foams, but these foams do not have the additional functional property of heat-setting that is characteristic of egg white proteins. Consequently, alcohol-washed soy proteins are not suitable as replacements for egg whites in angel food cakes (Eldridge and others, 1963).

Often it is necessary to make adjustments in the formulation before soy proteins can be added to a given food. Use of soy flour in bread frequently leads to a decrease in loaf volume but this can be overcome by adding oxidizing agents such as potassium bromate or dough conditioners such as sodium stearoyl lactylate (Tsen and Hoover, 1973).

Tests for evaluating the functional properties of soy proteins are largely empirical and hence not very reliable for predicting the performance of the proteins when they are added to a given food. The only reliable way to evaluate effectiveness of soy proteins for this purpose is to incorporate them into the formulation and prepare the finished food product. For more detailed discussions of the functional properties of soy proteins, see reviews by Johnson (1970), Wolf (1970), and Smith and Circle (1972).

Dietary Protein

Use of soy proteins at high levels as a dietary source of protein is a recent development. The best examples of this application are the textured soy proteins that serve as extenders or complete replacements for meat. Functional properties, however, are also important in these uses. In fact, success of soy proteins as meat extenders and meat analogs depends largely on their ability to assume a meat-like texture and to retain it during cooking.

The characteristic beany and bitter flavors of raw soybeans are difficult to remove completely by processing. Consequently, flavor has been a factor limiting the use of soy protein in some foods, especially those with bland flavors. Concentrates and isolates were developed to overcome the flavor of flours and grits, but the problem has not been completely solved for some potential applications such as dairy-type foods. Flavor may therefore be a barrier to extensive use of soy proteins for dietary purposes; that is, at levels high enough to be a significant source of protein in the diet.

Table 7 is a listing of food uses for the different soy protein forms currently marketed.

Flours and Grits

A major application of flours and grits is in bakery products. Rapid rises in the price of nonfat dry milk solids in recent years have nearly priced this commodity out of the market as a normal bread ingredient (Cotton, 1974). During July-September 1974, the wholesale price of nonfat dry milk was 57 cents per pound. As a result, soy flour blended with dry whey solids (byproducts of cheese manufacture) is used extensively at a level of

Table 7—Food uses of soy proteins

Protein form	Uses
Flours and grits	Bakery products:
	Bread, rolls, and buns
	Doughnuts
	Sweet goods
	Cakes and cake mixes
	Pancake and waffle mixes
	Specialty crackers and cookies
	Meat products:
	Sausages
	Luncheon loaves
	Patties
	Canned meats in sauces
	Breakfast cereals
	Infant and junior foods
	Confectionery items
	Dietary foods
Textured flours	Ground meat extenders
	Meat analogs (bacon-like bits, etc.)
Concentrates	Bakery products:
	Bread, biscuits, and buns
	Cakes and cake mixes
	Meat products:
	Sausages
	Luncheon loaves
	Poultry rolls
	Patties
	Meat loaves
	Canned meats in sauces
	Breakfast cereals
	Infant foods
	Dietary foods
Isolates	Meat products:
	Sausages
	Luncheon loaves
	Poultry rolls
	Dairy-type foods:
	Whipped toppings
	Coffee whiteners
	Frozen desserts
	Beverage powders
	Infant foods
	Dietary foods
Spun isolates	Meat analogs:
	Bacon-like bits
	Simulated sausages
	Simulated ham chunks
	Simulated chicken chunks
	Simulated bacon slices
	Meat extenders

1.5 to 2.0 pounds of soy flour per 100 pounds of wheat flour. The added soy flour-whey blend increases the protein content of the bread and improves the amino acid balance of the wheat proteins by supplying lysine. In other bakery applications, soy flours often are employed primarily for their functional properties. For example, addition of soy flour to doughnuts helps reduce absorption of fat during frying; in pancake and waffle mixes it contributes to desirable browning in the fried products. Soy proteins have good water-holding capacities; hence, help maintain freshness of bread. Some bakers add about 1 percent of a raw soy flour preparation (soy flour plus corn flour) to white breads for bleaching purposes. Raw soy flour contain the enzyme lipoxygenase which catalyzes reactions with polyunsaturated fatty acids that in turn cause bleaching of the yellow pigments in wheat. It is also claimed that bread flavor is improved as a result of action by the enzyme.

Soy flours are added to processed meats largely for functional purposes—binding, emulsion stabilization, and fat absorption (Rakosky, 1974). Textured soy flours are utilized extensively as extenders for ground beef both in retail markets (Wolford, 1974) and for institutional feeding such as school lunches, hospitals, and nursing homes. Smaller amounts of textured flours serve as replacements for meat—pizza toppings, simulated fried bacon bits, and related items.

Soy flour is also blended with cereals such as oats for infant and adult breakfast cereals. Some canned infant foods and infant cookies contain soy flour. Dietetic cookies and candy likewise have soy flour added to them.

Protein Concentrates

Protein concentrates find some of the same uses as flours. A major outlet for concentrates is in processed meats—sausages, meat balls, meat loaves, salisbury steak, and poultry rolls—for functional characteristics such as moisture absorption and fat-binding. Concentrates are blander and higher in portein content than flours. Certain ready-to-eat breakfast cereals and infant foods likewise contain protein concentrates.

Protein Isolates

Isolates are added to many of the same kinds of products as flours and concentrates—processed meats, infant foods, and dietary foods. Isolates are often used to replace the higher priced sodium caseinate in dairy-type items such as whipped toppings, liquid coffee whiteners, and frozen desserts. Instant cocoa mixes, instant breakfast preparations, and milk replacers are examples of beverage powder products containing protein isolates. Several milk-like formulas designed for infants who are allergic to cow's milk are based on soy protein isolates. Methionine is also added to these products to raise the nutritive value of soy protein to that of casein.

The ability to convert soy protein isolates into fibers has led to development of a variety of meat analogs. Until 1974, these products were sold primarily to the institutional trade—schools, nursing homes, and mental hospitals. Now, however, one company is selling frozen meat analogs in retail markets. In these products, spun fiber provides some of the chewiness that is characteristic of meats and can also supply a significant amount of dietary protein. A fried bacon bit analog containing spun isolate fibers has been available in many supermarkets for the past 5 years. Recently, a fresh, sliced bacon analog was introduced and another is currently in test markets.

The list of foods that contain soy proteins is growing but this fact is often obscured because the product labels generally do not call attention to individual components. Only on careful reading of the ingredient listing does it become apparent that the products contain soy proteins. For further information on food uses of soy proteins, the reader is referred to detailed reviews (Wolf, 1970; Wolf and Cowan, 1971; Smith and Circle, 1972) and the proceedings of the World Soy Protein Conference held in 1973 (American Soybean Association 1974).

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PRODUCTION ESTIMATES AND MARKET OUTLETS

W. J. Wolf
Northern Regional Research Laboratory

Soy flours and grits, the first edible soybean protein products produced commercially, have been available for about 40 years but they were not very successful initially because of poor flavor, dark color, and a high content of hulls. After World War II, however, the industry began to improve the flour and grits products and develop markets for them. The industry grew slowly and the more highly refined concentrates and isolates became available in 1959. By 1967, three processors produced more than 90 percent of the flours and grits, four firms prepared all the protein concentrates, and three companies manufactured all the isolates (Eley, 1968). Other companies have entered the business in recent years and now more than a dozen major firms manufacture and sell at least one form of soybean protein (table 8). Some new entries to the field are primarily in food manufacturing and also use soybean proteins as ingredients in their food items.

Production Estimates

Precise figures on the amounts of soybean proteins produced annually are not available because manufacturers consider this proprietary information. Two recent production estimates as well as recent selling prices are given in table 9. Figures for flours and grits include amounts used for pet foods and unknown amounts of these materials that are converted into other products (for examples, protein concentrates and textured soy flours) when further processing is carried out by other firms.

The most rapidly growing segment of the business has been the textured items that are mainly of the extruded soy flour type. This is also one of the most competitive areas because

Table 8—Principal U.S. producers of soybean protein products

Producer	Grits and flours			Concentrates	Isolates	Textured products	
	Defatted	Low fat*	Full fat			flours	isolates
Anderson Clayton Foods					+		
Archer-Daniels-Midland Co.	+	+	+	+**		+	
Cargill, Inc.	+	+***				+	
Carnation Co.					+		
Central Soya Co.	+	+	+	+	+	+	
FAR-MAR-CO.	+			+		+	
General Mills, Inc.						+	+
Grain Processing Corp.				+	+		
Griffith Laboratories				+		+	
Lauhoff Grain Co.	+					+	
Miles Laboratories, Inc.						+	+
Nabisco						+	
National Protein Corp.	+					+	
Ralston Purina Co.					+	+	+
A. E. Staley Mfg. Co.	+	+		+**	+****	+	
Swift & Co.	+			+		+	

* All producers of low-fat flours also offer lecithinated flours.
** Plant under construction.
*** Offers lecithinated but not low-fat flour.
**** Offers primarily pepsin modified isolates.

Note: Several additional companies supply specialty protein products from soybeans such as health foods, snacks, and confections. A listing of these companies can be found in the Soybean Digest Blue Book published annually by the American Soybean Association, Hudson, Iowa 50643.

many firms presently make and distribute textured products.

Table 9—Selling prices and production estimates for soybean proteins

Protein form	Price per pound [1]	Annual production 1972 [2]	1973 [3]
	Cents	*—Million pounds—*	
Flours and grits	9-15	352-500	450-600
Concentrates	27-35	40-50	55
Isolates	58-64	35-40	50
Textured items:			
Extruded flours	19-20	} 35-40	110
Spun isolates	50 and up		

[1] Prices as of February 1975.
[2] Lockmiller (1973).
[3] Lockmiller (1975).

Market Outlets

Quantitative information on market outlets is also difficult to obtain but estimates have been made that indicate relative magnitudes of the various outlets involved. Table 10 lists estimates made by Eley (1968) for soy flours and grits for 1967. Eley believed that use of soy proteins was increasing at 5 to 7 percent a year at that time; hence his figures are likely to be well below the current use. For example, Cotton (1974) has given a more up-to-date and detailed breakdown of the annual soy flour use in baked goods:

Use	*Million lbs.*
Bread	50
Specialty items and crackers	14
Doughnut mixes and cakes	7
Total	71

The total soy flour now used in baked goods is more than 40 percent higher than the estimate made for 1967 (table 10).

Table 10—Market outlets for soybean products, 1967 [1]

Outlet	Million pounds
Domestic:	
Baked goods	50
Meat products	30
Beverage products	10
Dry cereals and infant foods	6
Brewer's flakes	3
Pasta and macaroni	1
Miscellaneous	5–10
Subtotal	105–110
Exports	10
U.S. Government (overseas feeding)	100
Total	215–220

[1] Eley (1968).

Successful introduction of textured soybean proteins (mainly extruded flours or related products) into institutional food programs and at the retail level (ground beef and soy blends) plus addition of grits and flours to processed meats make meat products the largest single outlet for soybean proteins at present. In the institutional sector, the School Lunch Program is now the biggest consumer; about 25 million lunches are served daily. The School Lunch Program used about 9 million pounds of textured protein during the 1971-72 school year; in 1972-73, the amount is believed to have doubled (Bird, 1974). These products have been especially attractive to school officials faced with fixed budgets and rising prices for meat and also concerned with maintaining nutritional quality of meals distributed through their feeding programs (McCloud, 1974).

Outlets for concentrates are largely in processed foods—meats, breakfast cereals, and infant foods. The meat-processing industry is the largest of these outlets. Some concentrates with added vitamins and minerals are also used in the school lunch programs for extending meat dishes. Some companies mix concentrates with other soy protein forms in their textured products. For example, one firm blends concentrate with spun fiber and protein isolate to make a textured item intended for use as a meat extender.

The edible isolates are used almost exclusively by the food-processing industry. The major segments of the industry that incorporate isolates into their products are meat processing, meat analogs, dairy-type products, instant breakfast foods, and infant foods firms. The largest consumers of isolates are most likely the processors of meats and meat analogs. Predictions are that meat analogs will grow significantly in the future as discussed later (Market Growth). Isolates have been utilized in dairy-type products (whipped toppings, liquid coffee whiteners) and canned infant foods for several years. The use of isolates in instant breakfast items is recent and this application is probably the smallest at present but can be expected to grow if isolates are successful in displacing sodium caseinate in these kinds of foods.

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SOY PROCESSES, EQUIPMENT, CAPITAL, AND PROCESSING COSTS

G. C. Mustakas—Process Engineering
V. E. Sohns—Cost Engineering

Engineering and Development Laboratory
Northern Regional Research Laboratory

Five basic commercial edible soybean products and their processes for manufacture were chosen for this analysis: (1) full-fat soy flour, (2) defatted soy flour, (3) soy protein concentrates, (4) soy protein isolates, and (5) textured soy protein produced from soy flour. Selection of products was based on the idea that soy processing cooperatives would manufacture basic and intermediate products that could be marketed as raw materials as well as used for finished foodstuffs. Substantial investments have been made by the soybean industry in these intermediates; textured soy protein is the most recently developed product.

Cost estimates for the various processes described were prepared, largely from data contained in patent literature and other published sources, and from data supplied by equipment manufacturers. Although the various products are made commercially, data on such production are limited and not readily available, and thus inadequate for preparing cost estimates. Therefore, these cost estimates must be considered preliminary figures only and are intended to serve merely as guidelines for studying the feasibility of producing soy protein materials. Costs are reported as of mid-1974.

The procedure for estimating costs follows generally accepted techniques. Installations for various processes are considered to be adjuncts to already-existing soybean oil extraction plants. Costs are restricted to and include only facilities directly associated with the process. Therefore, costs for such items as steam-generating facilities and equipment for receiving, cleaning, storing, and grinding whole soybeans do not form part of the estimates. However, charges for various utilities and, where applicable, charges for receiving, storing, and preparing beans are added to other cost items.

The following cost items are included in production costs: raw materials (defatted flour and chemicals), utilities, labor and supervision, maintenance and fixed charges. Selling and administrative expenses and profit are not included. Processing costs for full-fat flour do not include the cost of soybeans. Utility rates are as follows: steam, $1.00 per 1,000 pounds; water, $0.25 per 1,000 gallons; electricity, $0.025 per kilowatt-hour; gas, $1.00 per 1,000 cubic feet. Maintenance for equipment is calculated at 5 percent a year on the erected equipment cost and for land and building, 2 percent a year of their cost. Fixed charges, consisting of depreciation, taxes, and insurance, are figured as follows: depreciation for equipment, 10 percent a year of erected equipment cost; for building, 3 percent a year of building costs (land not depreciated); taxes and insurance, 3 percent a year of estimated fixed capital investment.

Wages and salaries are estimated as follows: operators, $5.50 an hour; assistant or semiskilled operators, $4.00 an hour; supervisory help, 15 percent of labor costs; and payroll overhead, 25 percent of the base pay for labor and supervision.

The hypothetical plants for these estimates are equipped for sanitary operations and, in some instances, may include a clean-in-place (CIP) system. In an installation where a CIP system can be used, cleaning of equipment can be accomplished without dismantling it, thereby reducing labor requirements. A CIP system consisting of tanks, pumps, heat exchangers, and accessory items can be automated to various degrees to simplify operations.

Costs for treatment of waste streams and materials that are discharged from the various processes have not been included in the cost estimates. However, such costs cannot be ignored and for some locations may be a critical factor in determining the overall feasibility of installing a process.

Information supplied by DeLaval Separator Company, Poughkeepsie, N.Y., was helpful in preparing cost estimates for isolated soy protein and soy protein concentrate. Wenger Manufacturing, Sabetha, Kan., provided cost information on the production of full-fat soy flour and textured soy protein.

Production on Full-Fat Soy Flour by Extrusion Cooking

Extrusion has been adapted (Mustakas and others, 1964, 1970) in a system for cooking whole soybeans to obtain a full-fat soy flour of the highest quality for human consumption. By this method, a bland and palatable product with excellent nutritive value and good stability can be obtained. Oil cells of the seed are "ruptured" in the extrusion process due to the levels of temperature, pressure, and moisture existing in the barrel of the extruder. The extrusion cooking is performed in an extruder-screw configuration as shown in figure 6. During passage through the various sections, the material is gradually subjected to increased pressure and temperature. Finally, maximum pressure is created in the metering section. Temperature is partially controlled by steam jackets. Heat, of course, is also developed by screw pressure on solids during extrusion. Temperature of meal in the metering section reaches values above atmospheric boiling; however, boiling does not take place because the force is above atmospheric pressure. Thus, the extruder section is acting as a continuous pressure cooker. When the material extrudes through the final die or small apertures, the sudden great reduction in pressure causes the material to expand, thus rupturing the cells. This transformation of the material has been responsible for the process being called the "extrusion or expansion process." A similar process is being used in making cereal-type breakfast foods, as well as pet foods.

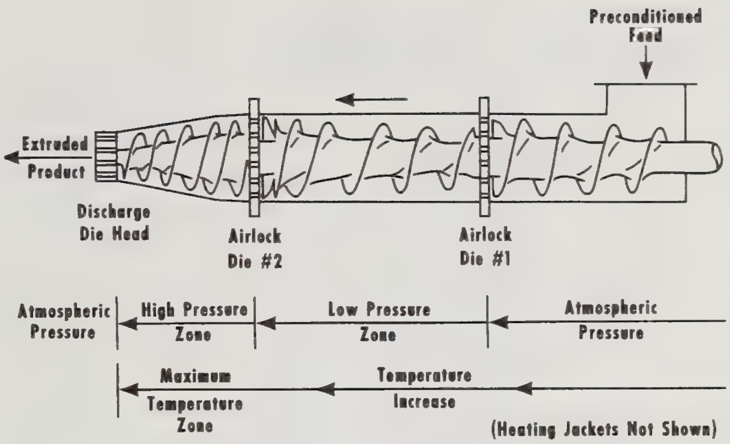

Figure 6.—Extruder screw standard configuration.

Figure 7 gives the sequence of operation for the continuous process of making full-fat soybean flour by extrusion cooking. First steps involve cracking, dehulling, flaking, and preconditioning of the raw material before extruding. Critical parts of the whole process are preconditioning, extrusion-cooking, and drying. Figure 8 shows the equipment layout arrangement for these operations. Flours of high nutritive value and good stability can be prepared by preheating unextruded soy bean flakes or grits to 200 to 212°F., premixing and adding sparge steam at 212°F., adjusting the moisture content to 18 to 21 percent, using a transport time of 1 to 1.5 minutes in the extruder with a final extrusion temperature reaching 250 to 290°F., and then drying, cooling, and grinding.

Estimated processing costs, excluding costs for soybeans, for a plant producing 4 tons per hour of full-fat soy flour (24,000 tons annually) from dehulled beans are 0.6 cent a pound of flour or 33 cents a bushel of whole beans. Fixed capital investment for such a plant is estimated at $200,000. This figure does not include the cost for land and building, storage facilities, and equipment for bean preparation. However, a charge for receiving and preparing the beans is added to the processing costs (table 11). Predicted yield is 90 pounds of full-fat soy flour from 100 pounds of whole beans. If soybeans are available at $6.00 a bushel ($0.10 a pound), estimated production

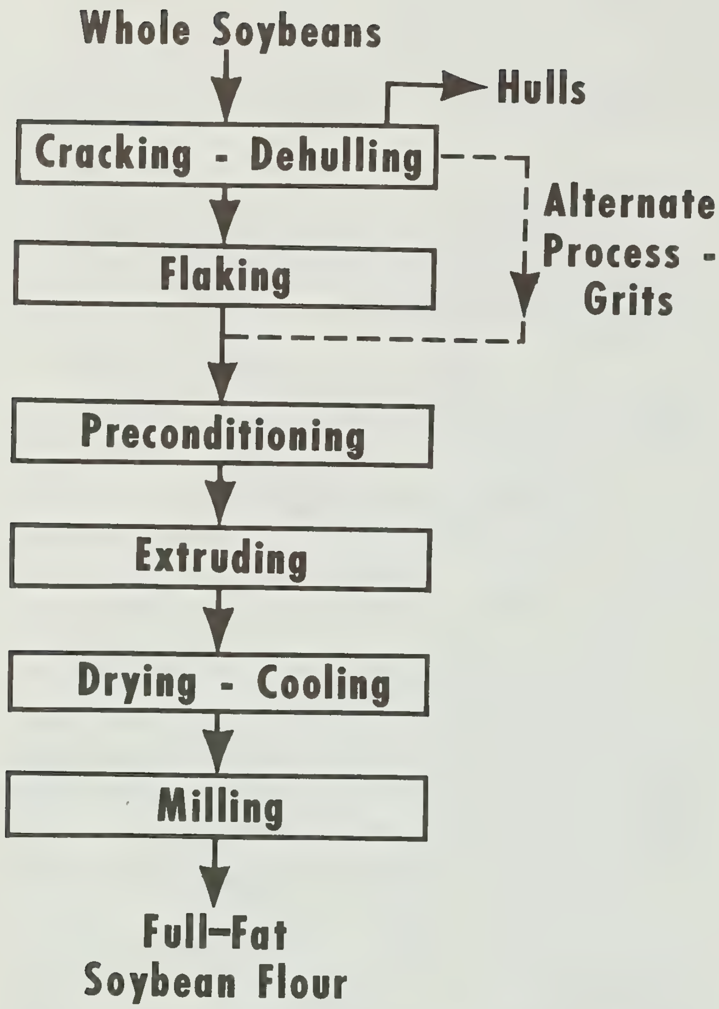

Figure 7.—Continuous extrusion process for the production of full-fat soy flour.

Table 11—Estimated processing costs per ton for producing full-fat soy flour by extrusion cooking of dehulled soybeans, 1974

Cost item	Dollars per ton of flour
Utilities:	
Steam: 2,600 lb, @ $1 a 1,000 lb	2.60
Electricity: 41 kWh, @ $0.025 a kWh	1.03
Water	Nominal
Labor and supervision:	
3 operators, @ $5.50 an hr	1.38
6 helpers, @ $4 an hr	2.00
Supervision	.50
Payroll overhead	.97
Maintenance and repairs, 5% a yr on $200,000	.42
Fixed charges:	
Depreciation, 10% a yr on $200,000	.83
Taxes and insurance, 3% a yr on $200,000	.25
Charge for receiving, grinding, and dehulling beans (1.1 tons)	2.50
Estimated processing costs per tons of flour	12.48
Estimated processing costs per lb of flour	.0062
Estimated processing costs per bushel of beans	.33

Notes

Cost of soybeans not included.
Plant capacity: 24,000 tons a year (96 tons a day).
Operations are conducted 24 hours a day 250 days a year.
Yield of flour: 90 pounds per 100 pounds of soybeans.
Estimated fixed capital investment: $200,000.
Estimated fixed capital investment does not include cost of land and building, facilities for steam and power generation, bean storage and preparation, product grinding and storage, and packaging.

costs, not including byproduct credit for hulls removed, are 11.7 cents per pound of flour.

Production of Defatted Soy Flour and Grits

Defatted soy flour and grits are the most elementary forms of high soy protein, yet they are the soy products used in the largest volume in foods. Only fully toasted or heat-treated flour and grits will be considered here. Products with minimum heat treatment are used directly for special purposes or for production of protein isolate.

When preparing soy flour and grits for human consumption, the soybeans should be thoroughly cleaned by standard procedures necessitating more than one cracking for complete separation of hulls (fig. 9) (De, S. S., 1971). Heating should be conducted under carefully controlled conditions to (1) secure optimum flavor and palatability, and (2) completely inactivate objectionable antibiological factors, unless the end-use requires retention of a high level of protein solubility or enzyme activity. Heating must not be so drastic as to damage the protein or reduce its nutritive value to unacceptable levels. Once optimum improvement in the factors noted above is effected, the desolventized toasted flakes should be cooled quickly to ambient temperatures. The fully processed flakes should have a light golden yellow color and a toasted and bland flavor, separate and distinct from that characteristic of raw soybeans. The product may be supplied in the form of grits (for example, a product that will pass through a 20-mesh screen and be retained on a 50-mesh

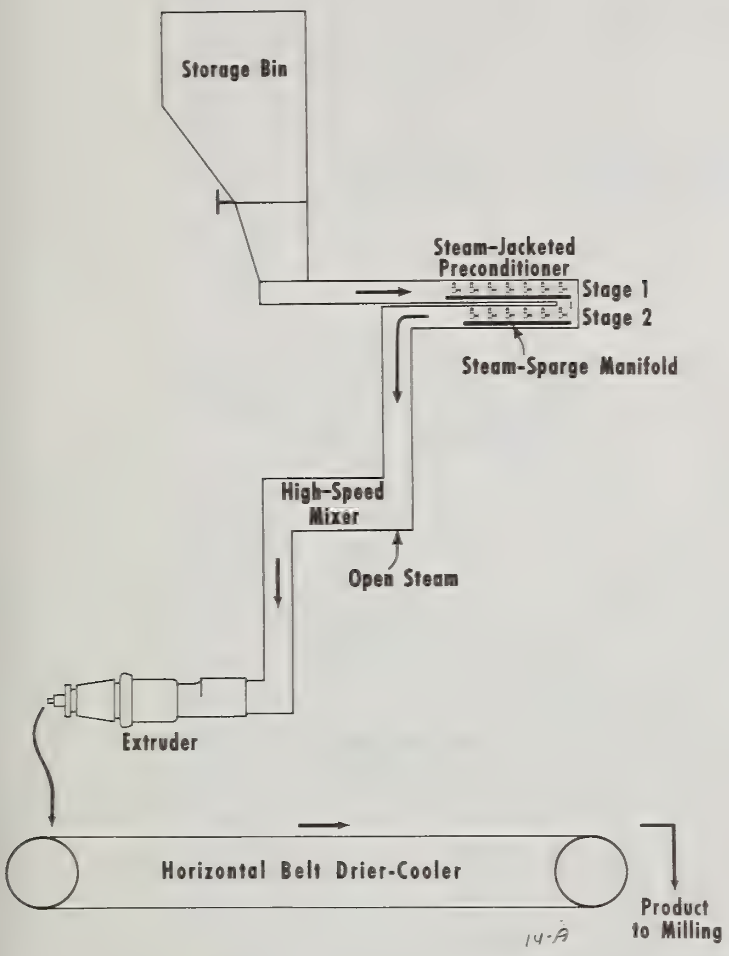

Figure 8.—Equipment layout for preconditioning, extruding, cooling, and drying steps.

screen) or ground to flour (97 percent will pass through a 100-mesh screen).

The minimum economic unit for a solvent extraction plant in foreign countries is considered to be 30 to 50 tons of beans a day, whereas in the United States, minimum capacity is about 150 tons a day.

Pretreatment.—All edible soybean products are derived from clean sound beans. Beans when received contain about 11 percent moisture and varying quantities of impurities.

The first processing step is to pass the beans through an aspirator/sieve cleaner which separates the incoming material into cleaned beans and trash (fig. 9). The cleaned beans are then dried to about 10 percent moisture. The beans next pass through a cracking process, where fluted rolls reduce the whole bean to fragments one-sixth to one-eighth of the original bean size. These fragments are then graded on sieves into two sizes, each stream passing through aspirators where the hulls are separated from the meal. The separated hulls are toasted and ground and used for animal feed. The cleaned, cracked meats now pass to a conditioner-cooker from which they emerge at a temperature of about 170°F. with a moisture content of 10 percent. This prepares them for flaking; flaking takes place between rollers, and the flakes emerge at a thickness of 0.008 to 0.010 inch. Flaking breaks down cell walls and makes available greater surface area for action of the solvent in the extraction process.

Extraction.—Solvent extraction (fig. 10) involves soaking oil-bearing material in a suitable solvent. The oil is dissolved in the solvent to form a mixture called miscella, which drains from the meal. The oil-rich miscella is evaporated to recover the oil and solvent. The meal is desolventized to yield a product with low oil and high protein content.

Solvent extraction is generally a continuous flooded process, the process being divided into stages to avoid back mixing of weaker and richer miscellas. This division allows almost continuous flooding with through stages of countercurrent washes to improve extraction efficiency.

The extractor is generally made up of a series of cells or baskets that rotate about a vertical axis. Each cell has an automatically operated outlet door fitted with a drainage screen. The raw material enters the extractor through a specially designed sealing feed screw and travels in the cell around the extractor. It is discharged through another automatically operated sealing device. During its passage around the extractor, the material is continuously soaked in a countercurrent segregated system of diminishing miscella strengths and finally washed with clean solvent. Soaking periods are adjusted to suit the materials being processed. The rotational speed of the extractor can be varied and the position of each miscella wash can be adjusted by the operator to suit different materials or different circumstances.

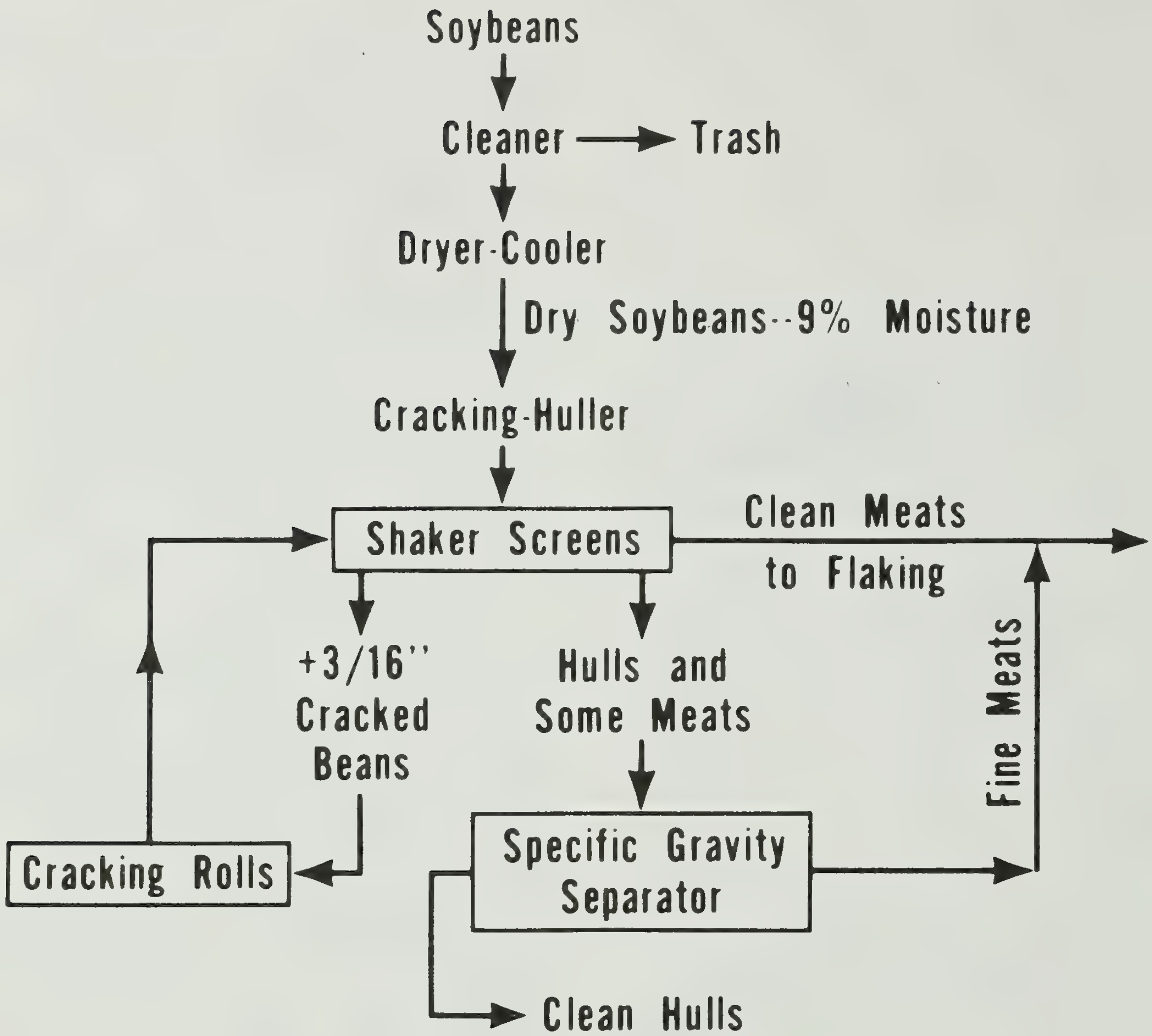

Figure 9.—Soybean dehulling installation.

Any fine particles that drain out of the cell bottom with the miscella are returned via a stage pump to the flooding device at the top of the extractor and recycled to the top of the cell. Clean filtered miscella leaves the bottom of each cell.

Desolventizing.—Desolventizing extracted soy flakes involves three simultaneous operations: elimination of solvent, destruction of urease, and toasting of the meal (giving it a golden-brown appearance). This necessitates the use of a desolventizer-toaster (DT) which combines the operations in a single unit. Flakes coming out of the extractor are defatted but still wet with solvent; they enter the upper compartment of the DT through a rotary valve or a similar device. Here they are in contact with steam either coming from the lower compartment or directly injected in the upper compartment.

The steam condenses on the flakes, evaporating the impregnated solvent at the same time. This evaporation is rather fast and practically all the solvent is eliminated in the second compartment. At this point, the moisture content of the flakes reaches 20 to 25 percent. The main purpose of the following compartments is to cook the flakes in a humid atmosphere that results in destruction of antinutritional factors. The time required for cooking is reduced by increases in temperature and moisture content. The purpose of the lower compartments is to reduce moisture to obtain the standard 12 to 13 percent moisture normally required for bagging. This is the conventional way of treating extracted soybean meal and it easily yields meals with a urease activity (the inactivation of urease by moist heat provides a quality control guide to deter-

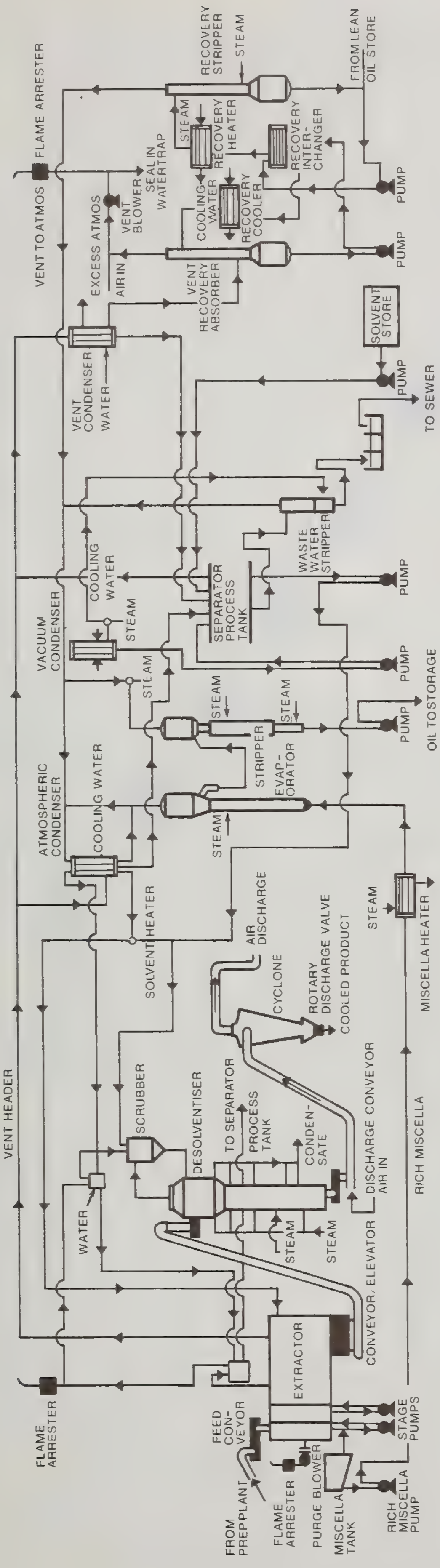

Figure 10.—Continuous solvent extraction plant.

mine the degree of heat treatment) under 0.02 (pH method).

Vapor Scrubbing.—Entrained fine solid particles in the vapor are removed by washing with solvent in a scrubbing device. The small amount of solvent used, plus entrained fines, is returned to the desolventizer.

Estimated Cost.—An estimate of the cost for preparing edible defatted flour and grits in a soybean processing plant has not been reported and cost information based on actual plant experience for the production of defatted flour and grits is not readily available. Processing costs in a soybean plant producing oil and meal for feed by the usual commercial procedure have been reported at about 25 cents a bushel of beans. If alterations were made in such a plant to permit production of edible defatted flour and grits also, it is expected that processing costs would increase but a few cents a bushel of beans.

Soy Protein Concentrate

The procedure described below was patented by Sair (1959, U.S. Patent No. 2,881,076) assigned to the Griffith Laboratories, Inc., and is based on extraction of defatted soybean meal with water at the isoelectric point of the protein (pH 4.6). Other processes are also in use.

An equipment flow diagram for this process is shown in figure 11. The procedure for producing soy protein concentrate is as follows:

Eleven hundred pounds of defatted soy flour are slurried into 1,400 gallons of cold water in a stainless steel tank. To this is added 66 pounds of HCl (37 percent by weight); the pH of the mixture is 4.6. After being agitated for 1 hour, the mass is centrifuged for separation of the curd and whey. The curd is washed twice by being resuspended in cold water with agitation as before and recentrifuged. The curd is an isoelectric residue and it may be dried for certain uses, or further treated as follows: To each 500 gallons of curd, raised in temperature to 110° to 120°F., is slowly added an aqueous solution of caustic soda, requiring about 12 to 14 pounds of NaOH, to raise the pH to 6.7 to 7.1. The neutralized con-

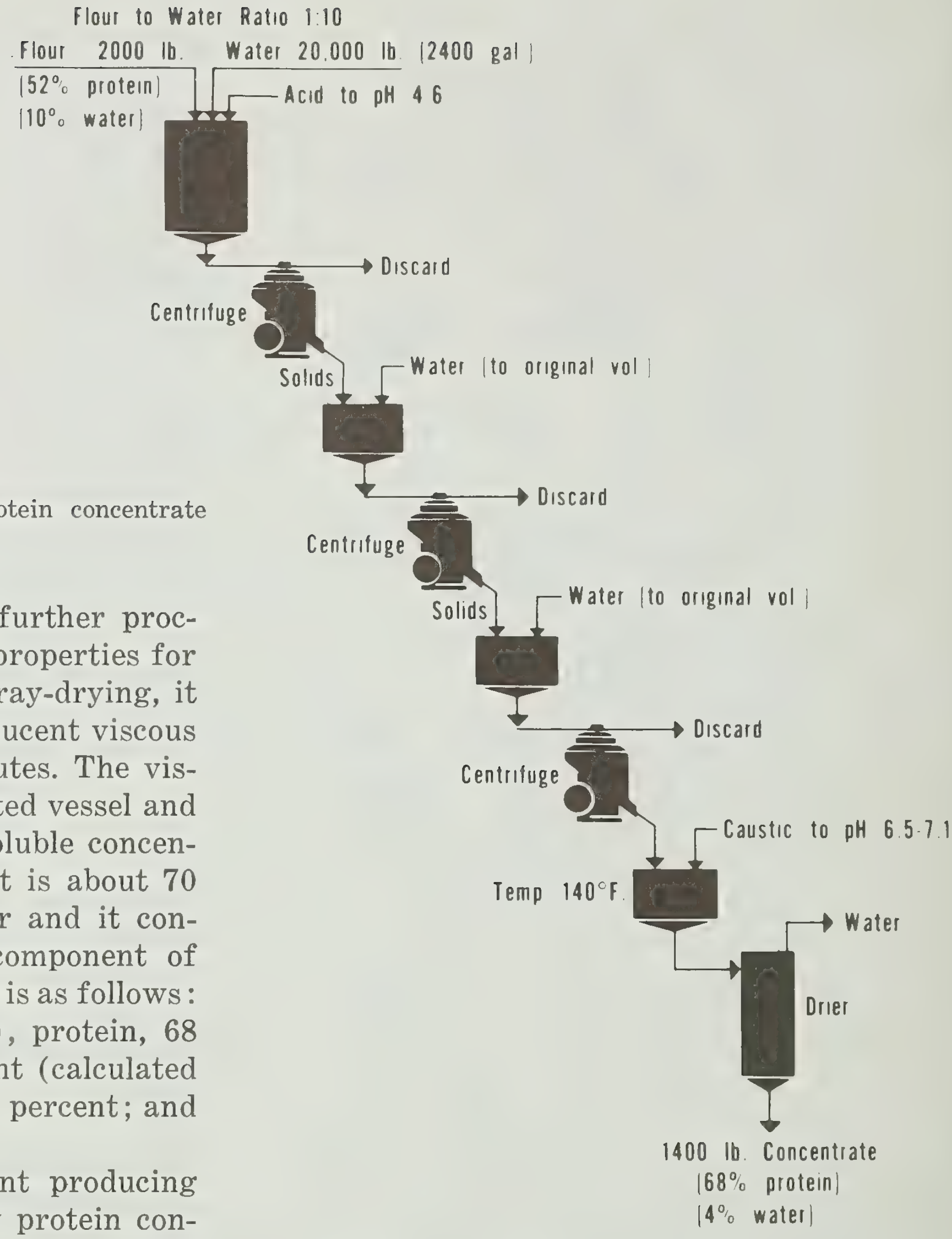

Figure 11.—Flowsheet for soy protein concentrate production.

centrate may be dried without further processing. However, to improve its properties for certain uses and to facilitate spray-drying, it is heated to 140°F. until a translucent viscous fluid is formed in about 30 minutes. The viscous fluid is drawn from the heated vessel and spray-dried to form a readily soluble concentrate. The yield of dried product is about 70 percent of the original soy flour and it contains 3.6 percent lysine as a component of protein. Typical product analysis is as follows: Moisture 3 percent (by weight), protein, 68 percent; reducing sugar, 1 percent (calculated as anhydrous dextrose); ash, 5.5 percent; and fat, 0.1 percent.

Estimated Costs.—For a plant producing 30 tons a day of neutralized soy protein concentrate (7,500 tons per year) from defatted soy flour, the estimated cost of production is about 25 cents a pound of concentrate, when defatted flour is 12 cents a pound (table 12). Estimated fixed capital investment for such a plant is about $4 million (table 13). Yield of concentrate has been predicted at 70 pounds from 100 pounds of flour when operations are conducted according to the procedure shown in figure 11. Costs for treatment of waste streams in the process would be in addition to the above costs.

Protein Isolate

Commercial production of protein isolate from soybeans for industrial uses began in Chicago in 1935 and has steadily increased since then. The industry was and still is primarily concerned with manufacturing adhesives for coating paper and other applications. The first plant producing edible grade soy protein isolate began operations in 1959. Since then, many developments have been reported on its uses in foods (De, S. S., 1971).

Although large quantities of both edible and industrial grades of soy protein isolate are currently produced in the United States, little published information exists on specification of design, equipment, and operation of the plants. Large-scale commercial know-how is limited to a few industrial organizations and several patents have been taken on the isolation of soy protein in its native state as well as

Table 12—Cost of producing neutralized soybean protein concentrate (68 to 70 percent protein) from defatted soybean flour (52 percent protein)

Cost item	Daily cost	Cost of concentrate
	Dollars	*Cents per lb.*
Raw materials:		
Defatted soy flour: 85,700 lb, @ $0.12 a lb	10,284.00	
Caustic: 935 lb, @ $0.13 a lb.	121.55	
Hydrochloric acid: 5,142 lb, @ $0.02 a lb	102.84	
	10,508.39	17.5
Utilities:		
Steam	Nominal	
Water (treated): 225,000 gal, @ $0.25 a 1,000 gal	56.25	
Electricity: 12,500 kwh @ $0.025 a kwh	312.50	
Gas 720,000 ft^3, @ $1 a 1,000 ft^3	720.00	
	1,088.75	1.8
Labor and supervision		
10 operators: @ $5.50 an hr	440.00	
3 helpers: @ $4 an hr	96.00	
Supervision: 15 percent of direct labor	80.40	
Payroll overhead	154.10	
	770.50	1.3
Maintenance		
Equipment: 5 percent a yr on $3,600,000	720.00	
Land and building: 2 percent a yr on $400,000	32.00	
	752.00	1.2
Fixed charges:		
Depreciation:		
Equipment: 10% a yr on $3,600,000	1,440.00	
Building: 3% a yr on $350,000	42.00	
Taxes and insurance: 3% a yr on $4,000,000	480.00	
	1,962.00	3.3
Estimated daily production costs	15,081.64	
Estimated production costs		25.1

Notes

Plant capacity: 7,500 tons a year (30 tons a day) when operations are conducted 24 hours a day 250 days a year.
Yield of concentrate: about 70 pounds per 100 pounds of defatted soybean flour.

Table 13—Fixed capital investment for a plant producing 7,500 tons a year (30 tons a day) of soy protein concentrate (68 to 70 percent protein) from defatted soybean flour (52 percent protein) [1]

Cost item	Dollars
Equipment, delivered	
6 continuous centrifuges, stainless steel for sanitary operations	750,000
1 spray dryer with auxiliaries for sanitary operations	325,000
Mixing tanks, stainless steel	160,000
Pumps, centrifugal and positive displacement	6,900
Clean-in-place system	22,000
Miscellaneous equipment	23,500
Total delivered equipment cost	1,287,400
Erected equipment cost	3,600,000
Land and building	400,000
Estimated fixed capital investment	4,000,000

[1] Yield of concentrate: About 70 pounds per 100 pounds of defatted soybean flour.

Note

Operating schedule: 24 hours a day, 250 days a year.

on improving flavor and functional characteristics for various uses.

Apart from sanitary conditions, production, and marketing, many differences exist between the isolate produced for food and that for industrial uses. Food-grade soy protein isolate is prepared with minimum chemical modification, ensuring no significant loss of amino acids or nutritional value. Protein isolate for industrial applications is generally modified by alkali or other chemical treatments which may lead to degradation of proteins and certain essential amino acids.

Advantages of Protein Isolation.—In addition to its high protein content, the isolated protein has a number of other advantages. Elimination of the insoluble and partly indigestible carbohydrate fraction results in removal of substances with undesirable physical characteristics; this fraction has a marked swelling tendency and makes any food into which it is incorporated bulky. In addition, isolation of protein removes many odoriferous and bitter elements that affect palatability and also harmful substances, such as trypsin inhibitors, hemagglutinins, etc., that impair the digestibility and utilization of the proteins.

Soy meal for protein isolation must have a high protein solubility. Unit operations in the commercial extraction of soybean oil with low boiling hydrocarbon solvents, usually hexane, have been discussed in the section on preparation of defatted flours. Very little denaturation occurs in the first stages of the solvent extraction stage. In most plants, some denaturation occurs in the desolventizer stage, but maximum changes take place in the steaming and toasting stages for improving flavor and nutritional value of the meal.

The high temperature in the toaster, in the presence of moisture, denatures the proteins and makes the meal unsuitable for protein isolation. Flash-type and vapor-phase desolventizers are found to be most suitable for producing meals with a high protein solubility or nitrogen dispersibility index (90 percent) (Milligan and others, 1974; Becker, K. W., 1971).

Solubilization of Protein from the Meal and Isolation.—About 92 percent of the protein from defatted soybean meal can be extracted with distilled water at a pH of 6.6. Contrary to the behavior of most vegetable proteins, low concentrations of salts reduce the dispersion of soy protein. For example, 0.1 normal sodium chloride in water lowers the dispersion from 92 percent to 45 percent and 0.0175 normal calcium or magnesium chloride lowers the dispersion of nitrogen components to 21 percent. This effect is overcome by increasing the concentration of salt or by raising the pH of the system. Most industrial sources of water are too high in salt concentration to give good yields of extracted protein and alkali has to be used to overcome the salt effect. In commercial practice, alkali dispersion at moderate pH and temperature levels is adopted to solubilize the protein, though acid dispersion at optimal pH range can also be used to disperse the protein. To ensure a high yield of protein, the meal is extracted with water at about pH 9.0. The insoluble residue in the dispersion, constituting nearly a third of the meal, is removed in a centrifuge and the protein precipitated with acid in the pH range of 4.6 to 4.1. In laboratory-scale operations, as much as 84 percent of the total protein of the meal may be recovered. Thus, with defatted meal containing 50 percent protein, the yield is 42 percent on the weight of the meal. In large-scale processing, however, yields are considerably lower, partly because of the lower water-to-meal ratio used in commercial processing. A yield of 30 percent on meal weight may be considered satisfactory under commercial conditions.

Factors Affecting the Extraction and Isolation of Protein from Meal.—Several factors, such as the nature of the extractant (solvent), pH, salts, extraction time and temperature, meal-to-extractant ratio, particle size of the meal, agitation, and the like, influence the dispersion characteristics of the nitrogenous constituents of the meal and are of paramount importance for optimal yield of the isolate in processing.

High yields of the isolate have been obtained by adjusting the pH of the extractant to about 9.0. The pH of the solution should be above 6.8, regardless of the dispersing agents used. The dispersibility of protein rises gradually, with increase reaching a maximum yield at about pH 11.0. Recent patents, however, prescribe a pH range of 7.0 to 7.6 for the extract.

The influence of low concentrations of salts (univalent and divalent cations) on the nitrogen dispersion behavior has been discussed in the previous section. It is, however, interesting to note that at the same pH, the isolated unhydrolyzed native protein is considerably less soluble in water than the original protein of the defatted meal. This difference has been attributed to the presence of potassium phosphate, dialyzable salts, and lecithin in the soybean meal and also to partial denaturation of protein during isolation. The behavior of phytin (a Ca-Mg salt of phytic acid believed to form complexes with soy protein) has been studied with respect to the isolation of the protein. Of the total phosphorus in soybeans, 70 percent exists in the form of phytin; the defatted meal contains nearly all the original phosphorus present in the beans. The solubility of phosphorus compounds in water extract of soybean meal varies with the pH of the solution like that of the major protein components. Phytin can be eliminated from the water extract of the meal by a combination of dialysis and treatment with anion exchange resins. Such treatment helps to obtain a high degree of purity in the isolated protein and several patents exist on the use of ion exchange resins for this purpose.

It has been reported that for the temperature range of 15° to 80° C., the total nitrogen extracted increased by about 0.25 percent per degree, and that the extraction reaches a maximum value at 80°C. In several patents, temperatures in the range of 55° to 60°C. have been specified. The amount of nitrogen extracted increased steadily in the first 30 minutes, reaching a nearly constant level after 45 minutes. Variations from 15 minutes to 2 hours are generally used industrially. Obviously, the extraction time and temperature are related to other factors, such as agitation, particle size, meal-to-extractant ratio, and other engineering and economic considerations.

Although large volumes of extractant may facilitate complete extraction of protein, their use in practice within specific time schedules poses many difficult engineering problems. For large-scale production, the most economic ratio is selected on the basis of the process for production of the meal, protein, and process cost. Generally, meal-to-extractant ratios in the range of 1:10 to 1:20 are recommended. Two successive extractions at 1:10 and 1:5 ratios are also used.

The particle size of soybean meal has a marked effect on the extraction efficiency. A mesh size of 100 or above is recommended for maximum extraction of protein. However, in the case of flake-type defatted soybean meal, the rate of extraction of protein is not very much affected by particle size.

Grinding soybean meal into fine particle size may increase or reduce the solubility of nitrogen, depending on the nature of milling action and the resultant heat of friction, if any. Dry grinding in a ball mill is known to exert a denaturing effect, probably due to the heat developed by the pounding action of the balls. However, wet grinding is very effective in increasing the water solubility of the protein.

The rate of extraction is obviously increased by agitation; however, moderate agitation to keep the meal freely suspended in the dispersion is sufficient for efficient extraction.

Separation of the insoluble residue from the aqueous alkaline dispersion presents many difficulties in large-scale operations. The coarse insoluble residue can be removed by passing the extract through an 80-mesh vibrating screen. Fine particles passing through the screen are removed in a continuous discharge-type centrifuge. Separation cannot be effected by filtration because of mucilaginous substances present.

Foaming during agitation or pumping generally leads to a decrease in the effective operating volumes of storage tanks and vessels. Steam-jets, ultrasonic vibrations, and mechanical devices of various kinds have been used to suppress foam. Often the use of antifoaming agents is essential. These include silicones, higher alcohols, and solutions of detergents in animal, vegetable, and mineral oils. Foam-detecting devices regulating automatic addition of antifoaming agents may be attached to the vessels.

Precipitation of the Extracted Protein.—Although a number of methods and protein precipitants are available, food-grade acids, commonly hydrochloric acid and acetic acid, are used for production of edible protein isolate. The type of acid used to lower the pH of the extract does not affect yield of protein. Precipitation of protein with calcium chloride has also been reported.

Soybean Whey.—The filtrate or centrifugate from wet protein curd contains water-soluble components of the meal, including albumins, proteoses, peptones, nonprotein nitrogen, sugars, trypsin inhibitors, urease, lipoxygenases, and other enzymes. This solution is known as "soybean whey" and its solids constitute about one-third of the original meal. Although several components of whey may have potential value, economic methods for their recovery have not yet been developed.

Some companies prefer to concentrate, dry, and add whey solids to animal feeds.

Washing of Protein Curd.—After acid precipitation, washing the protein curd is essential to remove acid and eliminate whey components. Two washing steps are recommended. Aqueous alcohols have also been used as washing media for special purposes.

Dewatering and Drying Proteins.—A vacuum drum filter is used to separate protein curd from whey, but for large continuous operation, automatic desludging centrifuges offer many advantages. The present-day practice is to use partial desludging centrifuges of the self-opening type or decanters to obtain a protein precipitate with as little whey as possible. The sludge obtained with a moisture content varying from 60 to 80 percent is spray-dried to yield the isoelectric form or neutralized with food grade alkali and spray-dried to yield the proteinate form. Some difficulties have been encountered in spray-drying, due to high viscosity of soy protein suspension, requiring precise control of process variables for ensuring good operation.

Yield and Quality of Protein Isolate.—Various literature references indicate that protein yields in the range of 30 to 40 percent of the weight of the defatted flake used can be obtained. Sound process design requires sanitary construction in stainless steel with both manual and automatic cleaning systems. Attention must be given to sanitary process control to prevent microbial growth and contamination.

Spray-dried protein isolate is a cream-white product, having a low flavor intensity, compared with other soy protein products. The flavor of isolated soy protein is often described as "cooked cereal-like" with certain off-notes. The proximate analysis of several commercial isolates is given in table 5 in the section, Kinds of Soy Products.

The process procedure and types of equipment required as suggested by Alfa-Laval for production of protein isolate are described in the followin section, and used as the basis for estimating production costs.

Alfa-Laval Process Procedure

Generalities.—A number of problems must be considered in selecting equipment for an ISP (isolated soy protein) plant (fig. 12); most important among these probably is the necessity of maintaining adequate hygienic standards.

All equipment has to be designed to make cleaning simple and efficient and to reduce manual labor; an automatic CIP (cleaning in place) system is particularly recommended to make sure that cleaning will be effective and correct.

Separation Equipment.—Separators are the most important components of an ISP processing plant.

Separators must produce a well-clarified effluent (that is, process liquid) and a solids phase containing the minimum of moisture so that losses are as low as possible and that drying the byproduct feed is economical.

One type of separator that seems to meet these diversified requirements is a solids-ejecting centrifugal separator with special modifications to suit this particular application. Experience has shown that separators of this type can be used to advantage for every kind of separation operation used in ISP processing and they also offer the advantages of using only one type of separator. The Alfa-Laval product line includes a number of separators that may be used for this purpose. Three models will be discussed here: a small pilot-plant separator (BRPX 207), a normal factory-size machine (BRPX 213) with three to four times greater throughput capacity, and a big factory separator (BRPX 317) with a throughput capacity about twice that of the BRPX 213.

Discharge of the solids phase from the separator is initiated ("triggered") either by a timer or by a self-sensing system that releases an impulse to empty the rotor ("bowl"). Being more sophisticated in design (and also somewhat more expensive), the latter system is insensitive to variations in the concentration of solids in the feed, producing a sediment of constant dryness along with a clean effluent. A particular advantage of this system is that it reduces losses and improves the economy of drying the byproduct feed.

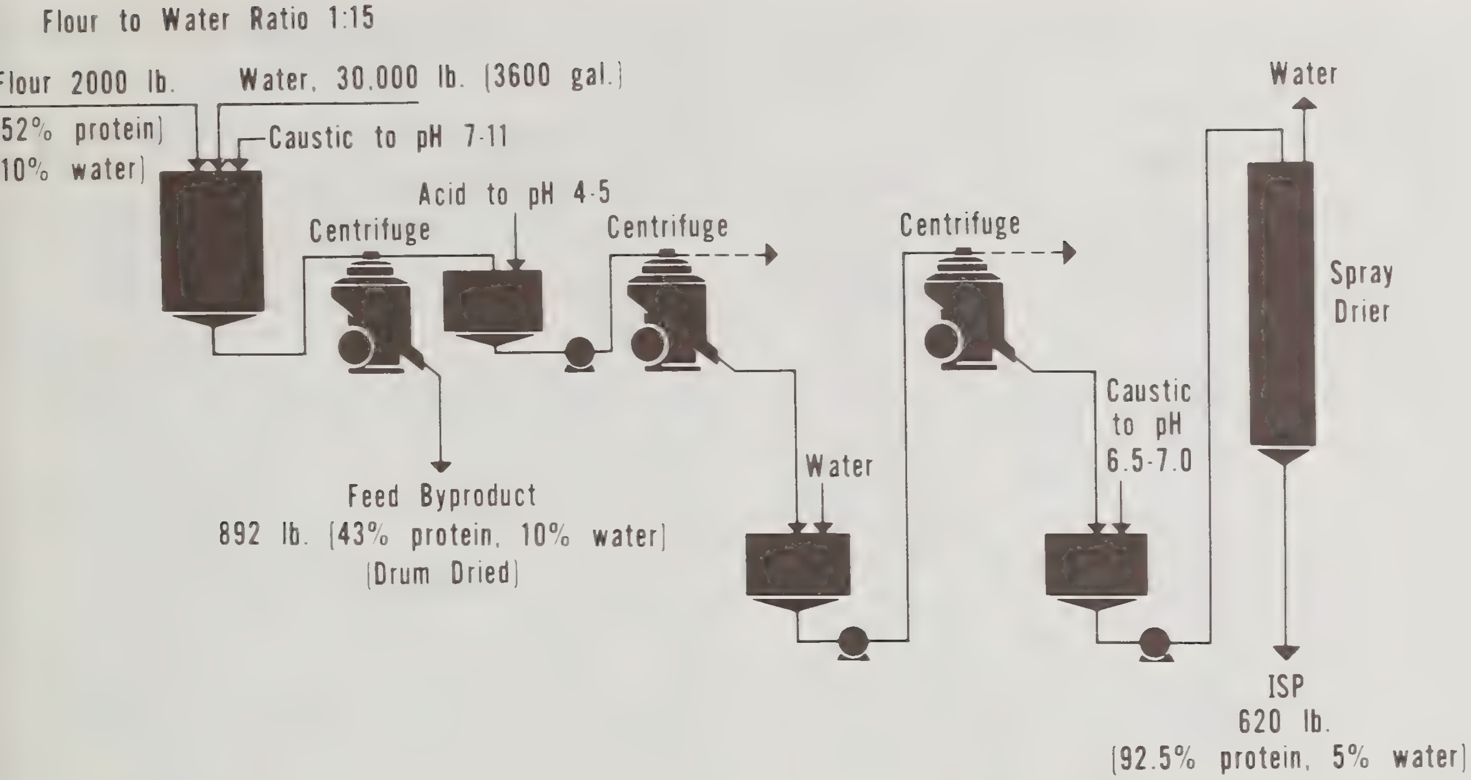

Figure 12.—Flowsheet for isolated soy protein production (ISP).

Tanks.—The tanks must have smooth surfaces and have to be designed to enable the cleaning liquid to flow at the speed required for efficient cleaning everywhere in the tanks. Pickups and agitators must be designed to exclude any pockets in which dirt would accumulate, yet facilitate efficient agitation without squashing any particles, which would complicate the subsequent separation process.

Pumps, Pipes, and Fittings.—Pipes, pumps, and valves have to be of sanitary design and must be arranged in such a way that there will be no pockets in which liquid might be trapped.

CIP.—A CIP plant is required, composed of tanks, pumps, valves, heat exchangers, and equipment to control the entire cleaning program.

Spray-Dryer for ISP.—The drying temperature has to be low and facilities for rapid cooling of the dried product are needed. In addition, the dryer should be easy to clean.

Dryer for Byproduct.—A drum dryer is suggested for drying the byproduct feed. The drying temperature is decisively important to the nutritional value of the product as well as to drying costs.

Processing Stages.—Basically, the ISP process is a batch process, meaning that you fill a tank, carry out a reaction, separate and remove the products obtained, and start a new batch.

Not only time but also pH and temperature influence the quality of the ISP product. In addition to affecting yield, these parameters greatly influence the performance of the separators and dryers. The amount of liquid used for alkaline extraction is important, whether one or two such extraction stages are preferred, as determined by the market prices of ISP and the byproduct feed, as well as the demands for quality and protein content of the latter.

A considerable amount of carbohydrates is dissolved and is present in the solution occluded in the acid precipitated curd. If a product rich in protein and poor in carbohydrate is desired, the curd must be washed, which inevitably leads to some loss of protein.

Process Design and Possibilities of Development.—A number of alternative possibilities exist for combining various components into a complete plant; the smallest conceivable plant is a pilot plant with a number of tanks arranged about a pilot-plant-size centrifugal separator used for the three necessary separation stages. It is possible, theoretically, to let such a plant expand by adding a similar centrifuge in each separation stage but the costs associated with the CIP and control systems will be just as high as in a big plant.

Starting with a factory-size separator, however, the pilot plant may be expanded at a later stage by the incorporation of two additional separators, thus developing it into a commercial production plant of the smallest size that may be expected to work at a profit. In a plant as described, each processing stage will include a tank and a separator. The following equipment will also have to be included in the plant: a neutralization tank, storage tanks with equipment for proportioning chemicals, pumps, pipes and fittings, and a CIP plant. A production plant of this design would have an output of about 2,200 pounds of ISP each 24 hours when working three shifts.

By adding more than one tank to each separator, the separators may be run continuously, increasing the plant output about three times.

When applying this system, the CIP may be carried out according to either of two methods: (1) the entire plant is stopped and remains inoperative during cleaning, or (2) a more complicated system is adopted in which certain parts of the plant are cleaned while others are operative. In the latter case, it will be necessary to include equipment for digital sequential control, but several hours of production will be gained every day, making the more complicated system more profitable. It will, in fact, pay for itself within a short period of time.

The plant output may be further increased by either of the following methods:

1. By arranging several processing lines in parallel, with certain equipment in common, such as the CIP and control equipment.

2. By employing several separators and tanks in parallel in each processing stage, with certain equipment in common, as mentioned above.

The latter solution offers the cheapest way of extending the plant. Sufficient space has to be reserved from the beginning, however. In principle, any throughput capacity may be chosen because centrifugal separators of a variety of sizes are available; the general rule is, however, that the fewer components, the less expensive the plant. In big plants, it is advantageous to use big tanks, with a number of subsequent separators in parallel. This also makes for the simplest CIP system.

Spray-drying is an expensive operation, demanding considerable investment; therefore, much attention has to be paid to the drying system of an ISP plant. Sometimes the isolate produced may be used directly in the moist state, provided that storage time is not excessive and that low-temperature storage can be provided.

In planning drying operations, it should be remembered that neither the feed byproduct dryer nor the ISP dryer can be extended step-by-step at a future expansion of the plant and that the only possibility of increasing the drying capacity is to increase the time of operation.

Estimated Costs.—A cost estimate for producing isolated soy protein by the process described and shown in figure 12 illustrates that, in a plant producing 20 tons per day of ISP (5,000 tons a year), the net cost to make it, including byproduct feed estimate of 9.4 cents a pound of ISP, is about 45 cents a pound. Defatted flour is assumed to be available to the process at 12 cents a pound. Calculations are based on a predicted yield of 31 pounds ISP per 100 pounds of flour and a byproduct feed recovery of about 45 pounds per 100 pounds of flour. Byproduct feed is priced at

Table 14—Cost of producing isolated soy protein (92 to 93 percent protein) from defatted soybean flour (52 percent protein)

Cost item	Daily cost	Cost of concentrate
	Dol.	*Cents per lb.*
Raw materials:		
Defatted soy flour: 129,000 lb., @ $0.12 a lb.	15,480.00	38.7
Caustic: 675 lb., @ $0.13 à lb.	87.75	.2
Hydrochloric acid	Nominal	......
Utilities:		
Steam: 175,000 lbs., @ $1 a 1,000 lbs.	175.00	
Water (treated): 385,000 gals. a day @ $0.25 a 1,000 gals.	96.25	
Electricity: 17,000 kWh @ $.025 a kWh	425.00	
Gas: 576,000 cu. ft. @ $1 a 1,000 cu. ft.	576.00	
	1,272.25	3.2
Labor and supervision:		
16 operators @ $5.50 an hr.	704.00	
3 helpers @ $4 an hr.	96.00	
Supervision @ 15% of direct labor	120.00	
Payroll overhead	230.00	
	1,150.00	2.9
Maintenance and supplies		
Equipment 5% a yr. on $4,900,000	980.00	
Land and building: 2% a yr. on $600,000	48.00	
	1,028.00	
Fixed charges:		
Depreciation:		
Equipment: 10% a yr. on $4,900,000	1,960.00	
Building: 3% a yr. on $540,000	64.80	
Taxes and insurance: 3% a yr. on $5,500,000	660.00	
	2,684.80	
Estimated daily production cost	21,702.80	
Estimated gross production cost		54.3
Byproduct credit: feed fractions, 1.45 lb. (65 per lb.) per lb. of ISP		9.4
Estimated net production cost, cents per lb. of ISP		44.9

Notes

Plant capacity: 5,000 tons a year (20 tons a day) of ISP when operations are conducted 24 hours a day, 250 days a year.
Yield of ISP per 100 pounds of defatted flour is about 31 pounds.
Yield of feed fraction per 100 pounds of defatted flour is about 45 pounds (43 to 44 percent protein).

Table 15—Fixed capital investment for a plant producing 5,000 tons a year (20 tons a day) of isolated soy protein (92 to 93 percent protein) from defatted soybean flour (52 percent protein) [1]

Cost item	Cost
	Dollars
Equipment, delivered:	
9 continuous centrifuges, stainless steel, for sanitary operations	1,125,000
1 spray dryer with auxiliaries, for sanitary operations, for drying ISP	126,000
2 drum dryers with auxiliaries, for drying feed fraction	290,000
Mixing tanks, stainless steel	185,000
Pumps, centrifugal and positive displacement	12,000
Clean-in-place system	25,000
Miscellaneous equipment—bins, scales, etc.	30,000
Total delivered equipment cost	1,793,000
Erected equipment cost	4,900,000
Land and building	600.000
Estimated fixed capital investment	5,500,000

[1] Yield of ISP: about 31 lb from 100 lbs of defatted soybean flour.

Note

Operating schedule: 24 hours a day, 250 days a year.

$130 a ton or 6.5 cents a pound (table 14). Estimated fixed capital investment for such a plant is $5,500,000 (table 15).

This process requires the treatment of several waste streams containing both suspended and dissolved solids, but costs for such treatment are not a part of the cost estimate. Whether actual recovery of solids from waste streams is economically feasible is problematical but will depend in part on pollution constraints or charges for sewage treatment.

Extrusion-Expanded Products—Textured Soy Proteins

Extrusion-expanded products — textured soy proteins—consist essentially of defatted oilseed flours, grits, meals, or flour-concentrate blends which have been subjected to HTST (high temperature short time) processing. The textured materials are usually available in dry form as flavored or bland, simple or compound products.

The essential characteristic of this process is that soy flours (about 50 percent protein) are used as the starting material. This plus greater simplicity of extrusion gives the process a cost advantage over the spinning (Boyer) process which uses isolated soy protein. A cooker-extruder is used to force the thermoplastic protein material through a die that controls the size and shape of the texturized material.

In operation (fig. 13), the extrusion is quite simple, but does require considerable experience in the handling of the equipment. Soybean meal that is substantially oil-free—about 0 to 5 percent by weight—is used. This meal is premoistened to levels of 15-40 percent, with special additives (such as salt and alkali) sometimes added to the preconditioning water. The mixture is agitated until homogenous. It is then fed to the extruder while the screw is rotated at a substantial speed. Steam and water are used in alternate jacket sections for heating and cooling. Cooling is usually carried out near the feed section of the extruder. The meal mixture is advanced within the extruder while being heated to high temperatures and subjected to elevated pressures. The mechanically worked mixture becomes a viscous fluid-type substance that is forced through a restrictor orifice after 30 to 60 seconds' retention time in the extruder. As the product emerges from the die outlet, the superheated moisture contained in the meal enters the substantially lower atmospheric pressure environment where flash-off evaporation of part of the moisture expands the product into a porous structure. Evaporation also cools the product substantially. The expanded product is very porous and has a fibrous network structure somewhat resembling that of meat. The product can be kept moist and used directly for food materials, or can be dried and packed conveniently for later use.

It rehydrates rapidly and completely within a few seconds, merely by adding water (usually about two parts for one part solids) to yield a product with excellent food characteristics.

Estimated Costs.—Cost of production of textured soy protein (TSP) by extrusion cooking of defatted flour has been estimated at 13 cents a pound when flour is priced at 12 cents a pound. This cost is based on a plant producing 2 tons of TSP an hour, or 12,000 tons a year. Estimated fixed capital investment—excluding cost for land and building, compounding and mixing systems, product storage, and packaging equipment—is $400,000 (table 16). In the cost calculations, it was assumed that no material was lost during processing. The cost would be increased appropriately if flavoring and other ingredients, such as coloring agents and vitamins or other nutrients, were added.

Table 16—Cost of producing textured soy protein (TSP, 20 lb. a cu. ft.) by extrusion cooking of defatted soy flour

Cost item	Dollars per ton of TSP [1]
Raw materials:	
Defatted soy flour, 2,000 lbs. @ $0.12 a lb.	240.00
Utilities:	
Steam: 3,500 lb. @ $1 a 1,000 lbs.	3.50
Electricity: 122 kWh @ $0.625 a kWh	3.05
Water	Nominal
Labor and supervision:	
3 operators @ $5.50 an hr.	2.75
6 helpers @ $4 an hr.	4.00
Supervision	1.01
Overhead	1.94
Maintenance and repairs: 5% a yr. on $400,000	1.67
Fixed charges:	
Depreciation: 10% a yr. on $400,000	3.33
Taxes and insurance: 3% a yr. on $400,000	1.00
Estimated cost of production per ton of TSP	262.25
Estimate cost of production, cents per lb. of TSP	13.1

[1] Assumes no loss of material during processing.

Notes

Plant capacity: 12,000 tons a year of TSP (48 tons a day).
Operations are conducted 24 hours a day, 250 days a year.
Estimated fixed capital investment is $400,000. Does not include cost for land and building, steam and power generating facilities, compounding and mixing systems, product storage, packaging, and similar items.

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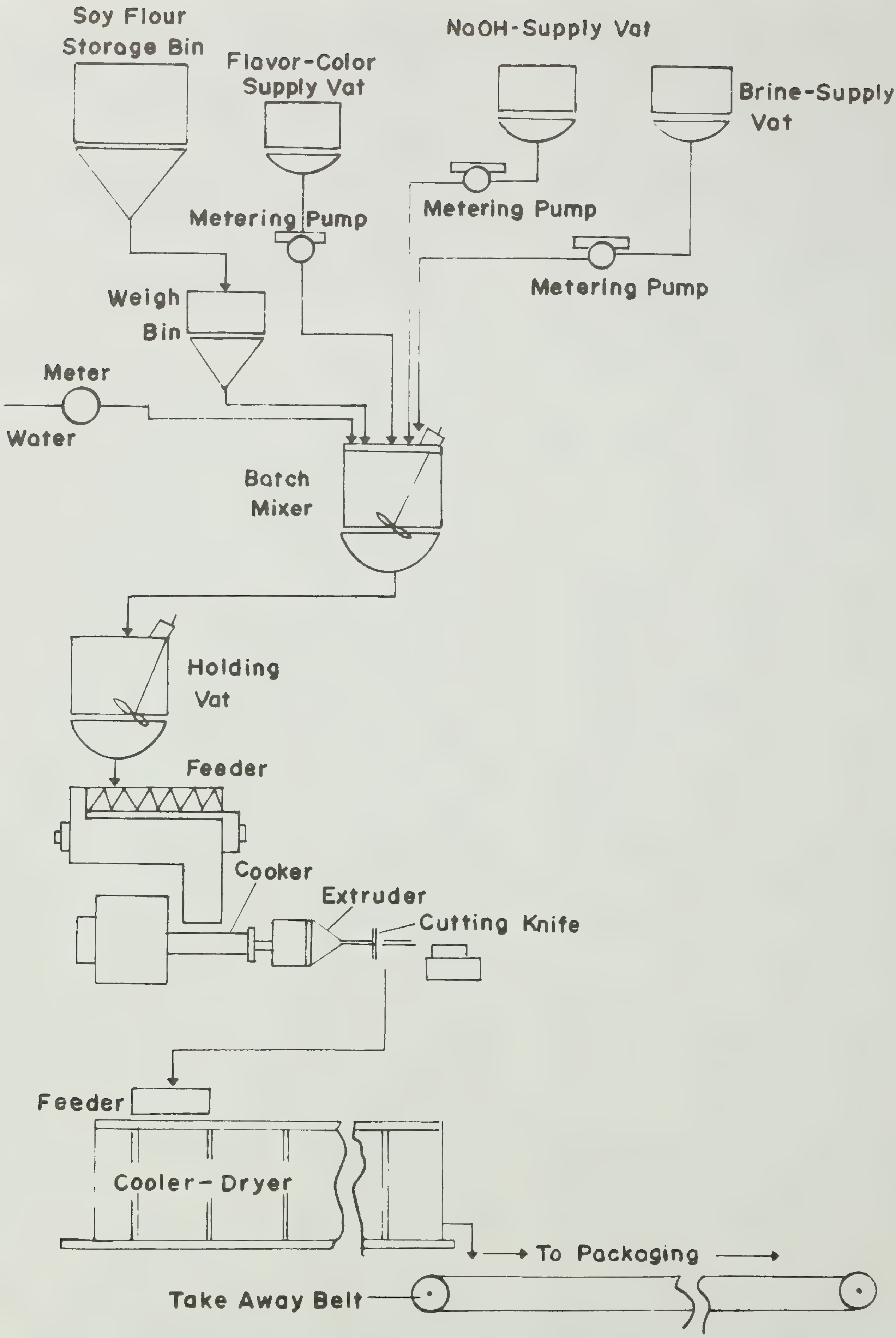

Figure 13.—Flowsheet for production of textured soy protein (Courtesy of *Food Engineering*).

CURRENT GOOD MANUFACTURING PRACTICE [1]

Assuring a high standard of sanitation in plants processing products for human consumption has been a U.S. Government policy of long standing. Current good manufacturing practice is the starting point for any sanitation program relative to food processing. The Food and Drug Administration describes this practice as a requirement of the Food, Drug, and Cosmetic Act. The most recent good manufacturing practice was published April 26, 1969, in the Federal Register and is reproduced here for basic guidance.

The Food and Drug Administration is studying the conditions applying to the production of edible soy protein to determine whether or not additional Federal regulation setting forth more specific sanitary standards are needed. There is uncertainty as to how soon this work will be complete. The practice reproduced here is, therefore, the most current guidance available.

§ 128.1 Definitions.

The definitions and interpretations contained in section 201 of the Federal Food, Drug, and Cosmetic Act are applicable to such terms when used in this part. The following definitions shall also apply:

(a) "Adequate" means that which is needed to accomplish the intended purpose in keeping with good public health practice.

(b) "Plant" means the building or buildings or parts thereof, used for or in connection with the manufacturing, processing, packaging, labeling, or holding of human food.

(c) "Sanitize" means adequate treatment of surfaces by a process that is effective in destroying vegetative cells of pathogenic bacteria and in substantially reducing other micro-organisms. Such treatment shall not adversely affect the product and shall be safe for the consumer.

§ 128.2 Current good manufacturing practice (sanitation).

The criteria in §§ 128.3 through 128.8 shall apply in determining whether the facilities, methods, practices, and controls used in the manufacture, processing, packing, or holding of food are in conformance with or are operated or administered in conformity with good manufacturing practices to assure that food for human consumption is safe and has been prepared, packed, and held under sanitary conditions.

§ 128.3 Plant and grounds.

(a) *Grounds.* The grounds about a food plant under the control of the operator shall be free from conditions which may result in the contamination of food including, but not limited to, the following:

(1) Improperly stored equipment, litter, waste, refuse, and uncut weeds or grass within the immediate vicinity of the plant buildings or structures that may constitute an attractant, breeding place, or harborage for rodents, insects, and other pests.

(2) Excessively dusty roads, yards, or parking lots that may constitute a source of contamination in areas where food is exposed.

(3) Inadequately drained areas that may contribute contamination to food products through seepage or foot-borne filth and by providing a breeding place for insects or microorganisms.

If the plant grounds are bordered by grounds not under the operator's control of the kind described in subparagraphs (1) through (3) of this paragraph, care must be exercised in the plant by inspection, extermination, or other means to effect exclusion of pests, dirt, and other filth that may be a source of food contamination.

(b) *Plant construction and design.* Plant buildings and structures shall be suitable in size, construction, and design to facilitate maintenance and sanitary operations for food-processing purposes. The plant and facilities shall:

(1) Provide sufficient space for such placement of equipment and storage of materials

[1] Amendment published in Federal Register: Part 128—Human Foods; Current Good Manufacturing Practice, April 26, 1969; 34 F.R. 6977.

as is necessary for sanitary operations and production of safe food. Floors, walls, and ceilings in the plant shall be of such construction as to be clean and in good repair. Fixtures, ducts, and pipes shall not be so suspended over working areas that drip or condensate may contaminate food, raw materials, or food-contact surfaces. Aisles or working spaces between equipment and between equipment and walls shall be unobstructed and of sufficient width to permit employees to perform their duties without contamination of food or food-contact surfaces with clothing or personal contact.

(2) Provide separation by partition, location, or other effective means for those operations which may cause contamination of food products with undesirable micro-organisms, chemicals, filth, or other extraneous material.

(3) Provide adequate lighting to hand-washing areas, dressing and locker rooms, and toilet rooms and to all areas where food or food ingredients are examined, processed, or stored and where equipment and utensils are cleaned. Light bulbs, fixtures, skylights, or other glass suspended over exposed food in any step of preparation shall be of the safety type or otherwise protected to prevent food contamination in case of breakage.

(4) Provide adequate ventilation or control equipment to minimize odors and noxious fumes or vapors (including steam) in areas where they may contaminate food. Such ventilation or control equipment shall not create conditions that may contribute to food contamination by airborne contaminants.

(5) Provide, where necessary, effective screening or other protection against birds, animals, and vermin (including but not limited to, insects and rodents).

§ 128.4 Equipment and Utensils.

All plant equipment and utensils should be (a) suitable for their intended use, (b) so designed and of such material and workmanship as to be adequately cleanable, and (c) properly maintained. The design, construction, and use of such equipment and utensils shall preclude the adulteration of food with lubricants, fuel, metal fragments, contaminated water, or any other contaminants. All equipment should be so installed and maintained as to facilitate the cleaning of the equipment and of all adjacent spaces.

§ 128.5 Sanitary facilities and controls.

Each plant shall be equipped with adequate sanitary facilities and accommodations including, but not limited to, the following:

(a) *Water supply.* The water supply shall be sufficient for the operations intended and shall be derived from an adequate source. Any water that contacts foods or food-contact surfaces shall be safe and of adequate sanitary quality. Running water at a suitable temperature and under pressure as needed shall be provided in all areas where the processing of food, the cleaning of equipment, utensils, or containers, or employee sanitary facilities require.

(b) *Sewage disposal.* Sewage disposal shall be made into an adequate sewerage system or disposed of through other adequate means.

(c) *Plumbing.* Plumbing shall be of adequate size and design and adequately installed and maintained to:

(1) Carry sufficient quantities of water to required locations throughout the plant.

(2) Properly convey sewage and liquid disposable waste from the plant.

(3) Not constitute a source of contamination to foods, food products or ingredients, water supplies, equipment, or utensils or create an insanitary condition.

(4) Provide adequate floor drainage in all areas where floors are subject to flooding-type cleaning or where normal operations release or discharge water or other liquid waste on the floor.

(d) *Toilet facilities.* Each plant shall provide its employees with adequate toilet and associated hand-washing facilities within the plant. Toilet rooms shall be furnished with toilet tissue. The facilities shall be maintained in a sanitary condition and kept in good repair at all times. Doors to toilet rooms shall be self-closing and shall not open directly into areas where food is exposed to airborne contamination, except where alternate means have been taken to prevent such contamination (such as double doors, positive air-flow systems, etc.) Signs shall be posted directing employees to wash their hands with cleaning soap or detergents after using toilet.

(e) *Hand-washing facilities.* Adequate and convenient facilities for hand washing and, where appropriate, hand sanitizing shall be provided at each location in the plant where good sanitary practices require employees to wash or sanitize and dry their hands. Such facilities shall be furnished with running water at a suitable temperature for hand washing, effective hand-cleaning and sanitizing preparations, sanitary towel service or suitable drying devices, and, where appropriate, easily cleanable waste receptacles.

(f) *Rubbish and offal disposal.* Rubbish and any offal shall be so conveyed, stored, and disposed of as to minimize the development of odor, prevent waste from becoming an attractant and harborage or breeding place for vermin, and prevent contamination of food, food-contact surfaces, ground surfaces, and water supplies.

§ 128.6 Sanitary Operations.

(a) *General maintenance.* Buildings, fixtures, and other physical facilities of the plant shall be kept in good repair and shall be maintained in a sanitary condition. Cleaning operations shall be conducted in such a manner as to minimize the danger of contamination of food and food-contact surfaces. Detergents, sanitizers, and other supplies employed in cleaning and sanitizing procedures shall be free of significant microniological contamination and shall be safe and effective for their intended uses. Only such toxic materials as are required to maintain sanitary conditions for use in laboratory testing procedures, for plant and equipment maintenance and operation, or in manufacturing or processing operations shall be used or stored in the plant. These materials shall be identified and used only in such manner and under conditions as will be safe for their intended uses.

(b) *Animal and vermin control.* No animals or birds, other than those essential as raw material, shall be allowed in any area of a food plant. Effective measures shall be taken to exclude pests from the processing areas and to protect against the contamination of foods in or on the premises by animals, birds, and vermin (including, but not limited to, rodents and insects). The use of insecticides or rodenticides is permitted only under such precautions and restrictions as will prevent the contamination of food or packaging materials with illegal residues.

(c) *Sanitation of equipment and utensils.* All utensils and product-contact surfaces of equipment shall be cleaned as frequently as necessary to prevent contamination of food and food products. Nonproduct-contact surfaces of equipment used in the operation of food plants should be cleaned as frequently as necessary to minimize accumulation of dust, dirt, food particles, and other debris. Single-service articles (such as utensils intended for one-time use, paper cups, paper towels, etc.) should be stored in appropriate containers and handled, dispensed, used, and disposed of in a manner that prevents contamination of food or food-contact surfaces. Where necessary to prevent the introduction of undesirable microbiological organisms into food products, all utensils and product-contact surfaces of equipment used in the plant shall be cleaned and sanitized prior to such use and following any interruption during which such utensils and contact surfaces may have become contaminated. Where such equipment and utensils are used in a continuous production operation, the contact surfaces of such equipment and utensils shall be cleaned and sanitized on a predetermined schedule using adequate methods for cleaning and sanitizing. Sanitizing agents shall be effective and safe under conditions of use. Any facility, procedure, machine, or device may be acceptable for cleaning and sanitizing equipment and utensils if it is established that such facility, procedure, machine, or device will routinely render equipment and utensils clean and provide adequate sanitizing treatment.

(d) *Storage and handling of cleaned portable equipment and utensils.* Cleaned and sanitized portable equipment and utensils with product-contact surfaces should be stored in such a location and manner that product-contact surfaces are protected from splash, dust, and other contamination.

§ 128.7 Processes and controls.

All operations in the receiving, inspecting, transporting, packaging, segregating, preparing, processing, and storing of food shall be conducted in accord with adequate sanitation principles. Overall sanitation of the plant shall be under the supervision of an individual assigned responsibility for this function. All reasonable precautions, including the following, shall be taken to assure that production procedures do not contribute contamination such as filth, harmful chemicals, undesirable micro-organisms, or any other objectionable material to the processed product:

(a) Raw material and ingredients shall be inspected and segregated as necessary to assure that they are clean, wholesome, and fit for processing into human food and shall be stored under conditions that will protect against contamination and minimize deterioration. Raw materials shall be washed or cleaned as required to remove soil or other contamination. Water used for washing, rinsing, or conveying of food products shall be of adequate quality, and water shall not be reused for washing, rinsing, or conveying products in a manner that may result in contamination of food products.

(b) Containers and carriers of raw ingredients should be inspected on receipt to assure that their condition has not contributed to the contamination or deterioration of the products.

(c) When ice is used in contact with food products, it shall be made from potable water and shall be used only if it has been manufactured in accordance with adequate standards and stored, transported, and handled in a sanitary manner.

(d) Food-processing areas and equipment used for processing human food should not be used to process nonhuman food-grade animal feed or inedible products unless there is no reasonable possibility for the contamination of the human food.

(e) Processing equipment shall be maintained in a sanitary condition through frequent cleaning including sanitization where indicated. Insofar as necessary, equipment shall be taken apart for thorough cleaning.

(f) All food processing, including packaging and storage, should be conducted under such conditions and controls as are necessary to minimize the potential for undesirable bacterial or other microbiological growth, toxin formation, or deterioration or contamination of the processed product or ingredients. This may require careful monitoring of such physical factors as time, temperature, humidity, pressure, flow-rate and such processing operations as freezing, dehydration, heat processing, and refrigeration to assure that mechanical breakdowns, time delays, temperature fluctuations, and other factors do not contribute to the decomposition or contamination of the processed products.

(g) Chemical, micro-biological, or extraneous-material testing procedures shall be utilized where necessary to identify sanitation failures or food contamination, and all foods and ingredients that have become contaminated shall be rejected or processed to eliminate the contamination where this may be properly accomplished.

(h) Packaging processes and materials shall not transmit contaminants or objectionable substances to the products, shall conform to any applicable food additive regulation (Part 121 of this chapter), and should provide adequate protection from contamination.

(i) Meaningful coding of products sold or otherwise distributed from a manufacturing, processing, packing, or repacking activity should be utilized to enable positive lot identification to facilitate, where necessary, the segregation of specific food lots that may have become contaminated or otherwise unfit for their intended use. Records should be retained for a period of time that exceeds the shelf life of the product, except that they need not be retained more than 2 years.

(j) Storage and transportation of finished products should be under such conditions as will prevent contamination, including development of pathogenic or toxigenic micro-organisms, and will protect against undesirable deterioration of the product and the container.*

§ 128.8 Personnel.

The plant management shall take all reasonable measures and precautions to assure the following:

(a) *Disease control.* No person affected by disease in a communicable form, or while a carrier of such disease, or while affected with boils, sores, infected wounds, or other abnormal sources of microbiological contamination, shall work in a food plant in any capacity in which there is a reasonable possibility of food or food ingredients becoming contaminated by such person, or of disease being transmitted by such person to other individuals.

(b) *Cleanliness.* All persons, while working in direct contact with food preparation, food ingredients, or surfaces coming into contact therewith shall:

(1) Wear clean outer garments, maintain a high degree of personal cleanliness, and conform to hygienic practices while on duty, to the extent necessary to prevent contamination of food products.

(2) Wash their hands thoroughly (and sanitize if necessary to prevent contamination by undesirable micro-organism) in an adequate hand-washing facility before starting work, after each absence from the work station, and at any other time when the hands may have become soiled or contaminated.

(3) Remove all insecure jewelry and, during periods where food is manipulated by hand, remove from hands any jewelry that cannot be adequately sanitized.

(4) If gloves are used in food handling, maintain them in an intact, clean, and sanitary condition. Such gloves should be of an impermeable material except where their usage would be inappropriate or incompatible with the work involved.

(5) Wear hair nets, headbands, caps, or other effective hair restraints.

(6) Not store clothing or other personal belongings, eat food or drink beverages, or use tobacco in any form in areas where food or food ingredients are exposed or in areas used for washing equipment or utensils.

(7) Take any other necessary precautions to prevent contamination of foods with microorganisms or foreign substances including, but not limited to, perspiration, hair, cosmetics, tobacco, chemicals, and medicants.

(c) *Education and training.* Personnel responsible for identifying sanitation failures or food contamination should have a background of education or experience, or a combination thereof, to provide a level of competency necessary for production of clean and safe food. Food handlers and supervisors should receive appropriate training in proper food-handling techniques and food-protection principles and should be cognizant of the danger of poor personal hygiene and insanitary practices.

(d) *Supervision.* Responsibility for assuring compliance by all personnel with all requirements of this Part 128 shall be clearly assigned to competent supervisory personnel.

§ 128.9 Exclusions.

The following operations are excluded from coverage under these general regulations; however, the Commissioner will issue special regulations when he believes it necessary to cover these excluded operations: Establishments engaged solely in the harvesting, storage, or distribution of one or more raw agricultural commodities, as defined in section 201 (r) of the act, which are ordinarily cleaned, prepared, treated or otherwise processed before being marketed to the consuming public.

MARKET GROWTH

W. J. Wolf
Northern Regional Research Laboratory

Various factors have helped to establish present markets for soybean proteins and also will influence the growth of future markets:

1. Economics
2. Growth of processed foods market
3. Flavor characteristics
4. Functional properties
5. Nutritional properties
6. Government regulations
7. Consumer acceptance

Not all of these determinants of growth are of equal importance, but some of them are interrelated. For example, flavor of a protein ingredient can have a favorable or unfavorable effect on consumer acceptance. On the other hand, if Government regulations prohibit or severely limit protein additives in a particular food, low price and excellent functional properties are of little or no importance.

Economic Factors

Soybean proteins are ingredients for processed foods and, therefore, compete with other protein sources used for this purpose, particularly animal proteins such as milk and egg proteins. Economics is one of the strongest forces influencing future markets because, if other factors such as flavor and functionality are equal, manufacturers will select the lowest cost ingredient. Economics is often the wedge that opens doors to new markets. In many instances, soybean proteins do not meet all the desired criteria for complete replacement of a higher priced protein, but partial substitution is possible and is made. This in turn leads to further improvement of the desired qualities and to modification of formulations with the result that ultimately more of the animal protein is displaced. For example, one company now markets a partial egg yolk replacer that contains modified vegetable proteins and is intended for the bakery trade. Use of this product is probably still small. However, with time and a continued favorable price differential between egg yolks and the replacer, the market is likely to grow because the bakers have an incentive to use the product, and the ingredient supplier is encouraged to make further improvements in the properties of the alternate protein.

Milk Proteins Versus Soybean Proteins.—The economic advantage of soybean proteins over animal proteins is clearly shown by comparing soybean proteins with those from milk. Selling prices per pound of ingredient as well as per pound of protein and annual consumption figures for the two protein groups are given in table 17. Flours and grits, the soybean products of lowest protein content, are higher in protein than all of the milk proteins except casein. Indeed, flours and grits sell for about the same price as whey but contain four times as much protein.

Table 17—Domestic consumption, protein content and prices of milk and soy proteins used for processed foods

Protein	Consumption [1]	Protein content	Bulk price per lb.[2]	Price per lb. of protein
	Million lb.	*Pct.*	*Dol.*	*Dol.*
Milk:				
Nonfat dry milk	1.056	36	0.57	1.59
Dry whole milk	21	26	0.63	2.42
Casein	85	95	0.90-1.20	0.95-1.26
Whey	231	13	0.11-0.15	0.85-1.15
Soybean:				
Flours and grits	150	50	0.11-0.14	0.22-0.28
Concentrates	55	70	0.30-0.38	0.43-0.54
Isolates	50	95	0.58-0.64	0.61-0.67
Textured flours	90	50	0.21-0.24	0.42-0.48
Textured isolates	20	20 [3]	0.50+	2.50+

[1] Data for 1973. Milk protein data, except casein figure, from U.S. Dept. Agr., Econ. Res. Serv., Dairy Situation (1974). Soy protein figures estimated from Lockmiller (1975) assuming that all concentrate and isolate production is consumed domestically.
[2] Approximate prices January 1975. Low price for casein is for acid form and high price is for sodium caseinate.
[3] Frozen, 60 percent moisture basis.

Nonfat dry milk has been in short supply and has more than tripled in price over the past few years with the result that it is too expensive to use as a normal bread ingredient (Cotton, 1974; Singleton and Robertson, 1974). Bakers have, therefore, begun replacing nonfat dry milk in baked goods with various soy-derived ingredients, including blends of: cheese whey, whey protein, soy flour plus vitamins and minerals; cheese whey, soy flour, and buttermilk; and cheese whey, sodium caseinate, soy protein isolate, and soy flour. These and related milk replacers are also used by other food processors who have traditionally used nonfat dry milk. It is unlikely that nonfat dry milk will drop to its former low price; hence, soybean products can be expected to take increasing portions of this market in the future. Nonetheless, the present high-volume market for nonfat dry milk (table 17), despite its high price, indicates that soybean products now available may not be satisfactory replacements for many applications. It will, therefore, be necessary to develop desired qualities in the soybean products if they are to be successful in displacing the milk product.

Casein is another example of an animal protein that has priced itself out of certain markets. When casein is compared with its soybean counterpart, the isolates, we see that sodium caseinate (the principal form of casein used in processed foods and selling at $1.20 a pound) sells at almost twice the price of the soybean product. Virtually all of the casein used domestically is imported, and there are no trends toward lower prices in the near future. Consequently, substitution of soybean protein isolates for sodium caseinate has occurred in items such as liquid coffee whiteners, instant breakfast products, and whole milk powder replacers. These trends will undoubtedly continue in the future as flavor and functional properties of soybean concentrates and isolates are further modified and improved.

Growth of Processed Foods Market

Processed foods are predicted to grow continually for the next several decades. Because soybean proteins are used extensively in these products, markets for soybean-based ingredients are also expected to grow substantially. Table 18 shows projected growth of protein utilization in processed foods to 1980 as estimated by Hammonds and Call (1972) based on an extensive survey made in 1970. This projection includes the portion of processed foods also referred to as fabricated foods. Bread, ice cream, and margarine are fabricated foods of long standing, whereas textured vegetable proteins, coffee whiteners, and instant breakfast items are examples of recently developed products of this type. Fabricated foods are made from ingredients of various sources to supply fat, protein, and carbohydrates, plus a number of minor additives as needed. Increasingly, fabricated foods are designed from the outset to include soybean proteins to take advantage of the economies involved.

The most rapidly growing portion of the protein market is in processed meats. Because of the volume of meats involved, this is also

Table 18—Protein use, 1969, and growth in use, projected 1980

Use	Annual growth rate	Protein	
		1969	1980
	Pct.	*Ml. lb.*	
Baby food	1.0	3.5	3.9
Baked goods and baking needs:			
Snack food	6.0	10.0	19.0
All other	1.5	91.0	107.1
Breakfast food:			
Instant breakfast	8.0	12.8	29.8
All other	1.7	5.1	6.2
Candy	3.0	16.6	23.0
Canned and processed meat	19.3	92.2	642.4
Coffee whitener	6.0	12.0	22.8
Dairy products:			
Imitation milk	......	......	188.0
Synthetic ice cream	5.0	3.8	6.5
All other	1.0	98.1	109.1
Desserts and toppings	6.0	31.7	60.0
Diet drink	2.0	8.4	10.5
Frozen food	3.6	3.8	5.6
Macaroni/pasta products	3.0	1.5	2.1
Pet food	5.4	[1] 229.3	426.0
Soup	0.0	1.5	1.5
Subtotal		621.3	1,663.5
All other uses	9.3 [2]	207.3	555.0
Total		828.6	2,218.5

[1] Includes 51.9 million lb. from ingredients not fit for human consumption.
[2] Weighted average growth rate for all protein ingredients.
Source: Hammonds and Call (1972).

predicted to be the largest market for protein ingredients. About one-half of the growth is expected to be in meat extenders and the other half in meat analogs.

Table 19 shows predictions of growth for fabricated foods for the next 5 years. The sector projected to grow most rapidly is vegetable protein products, although many products in other categories may already contain some form of soybean protein (for example, dairy substitutes, dietetic foods, and prepared cereals). A projection of uses for textured vegetable proteins according to markets and by types (extruded flour versus textured isolates) is given in table 20. At present, extruded

Table 19—Sales of fabricated foods, 1972 and projections for 1976 and 1980

Food for human consumption	Sales in— 1972	1976	1980
	Million dollars		
Dairy substitutes	847.4	994.2	2,527.4
Beverages	157.3	211.8	273.9
Snack foods	2,001.8	2,467.3	3,066.1
Prepared desserts	60.0	82.0	111.0
Salad dressings:			
Spoonable	313.6	370.9	439.2
Pourable	122.6	172.0	238.1
Vegetable protein products	82.0	316.5	1,531.9
Dietetic foods	39.5	47.7	96.0
Prepared cereals	670.0	753.0	848.0
Cookies and crackers	1,558.0	1,686.0	1,825.0
Cake and roll mixes	230.5	240.6	250.4
Breakfast bar products	68	86	109.0
Total	6,150.7	7,428.0	11,316.0

Source: Frost and Sullivan, Inc., New York, "The Fabricated Foods Market," cited by Iammartino (1974).

Table 20—Market projections for textured vegetable proteins, selected years, 1975-2000

	Use in— 1975	1980	1985	1990	2000
	Million pounds				
School lunch	113	180	210	270	348
Public eating	28	352	1,095	1,968	2,372
Federal institutions	12	27	40	58	79
Commercial and others	35	1,248	3,139	7,423	9,413
Total	188	1,807	4,484	9,719	12,212
Extruded type	117	1,066	2,107	3,888	4,885
Spun type	71	741	2,377	5,831	7,327
	Million dollars				
Sales [1]					
Extruded	47	426	843	1,554	1,954
Spun	64	667	2,139	5,247	6,594

[1] Assumes average price (constant through 2000) for extruded is \$0.40/lb; spun, \$0.90/lb.
Source: Business Communications Co., cited by Iammartino (1974).

flour is the major product type sold, and most of it is being consumed by school food services. However, predictions are that the spun type of product will become the predominant form sold and that large increases in usage will occur in public eating and commercial outlets. A large untapped market in the institutional trade consists of nursing homes, convalescent centers, and hospitals where meat analogs could be used in controlled diets with standardized caloric, nutrient, and salt compositions (Robinson, 1972).

Three years ago only one textured vegetable protein product (fried bacon-like chips) had made significant penetration of the consumer market. The next major introduction of textured products in the retail markets came in 1973 when beef prices rose to high levels and ground beef-textured soybean protein blends were offered at \$0.10 to \$0.20 a pound below ground meat prices. Consumer acceptance of the blends was good (about 25 percent of total ground meat sales) until beef prices declined again. In late 1974, the market of the beef-soybean blends was estimated to have dropped to about 15 percent of ground meat sales (Brudnak, 1974). The textured products derived from soy flour are also available in the supermarkets in a dry form for use in the home, but sales of these items are probably small. It is likely that more sophisticated and appealing products must be offered in the retail outlets before large markets become established. One company moved in this direction in 1974 by introducing frozen analogs of pork sausage and ham slices (Brudnak, 1974). More recently this same company also introduced a frozen sliced bacon analog and another firm is test marketing a refrigerated bacon analog (Anon., 1974).

Flavor Characteristics

Flavor has been a major deterrent to use of soybean proteins in a variety of foods. Improvements are being made, however, and it is likely that progress will continue. A growing number of companies are working on the problem; with the present economic advantage of soybean proteins over milk and other animal proteins, it is also possible to use more complex (and expensive) processes to obtain products with less residual soybean flavor. As the flavor problem becomes better understood, one can anticipate changes in the overall processing of soybeans. At present, the protein portion of the business is basically an upgrading of a byproduct from oil extraction; that is, defatted flakes. Eventually, processing may be modified to put the emphasis on quality of the protein rather than the oil.

Functional Properties

Proteins have many different properties, and as the food industry developed, certain proteins were found to have unique characteristics ideally suited for certain applications. Examples are the baking properties of wheat gluten and the whipping properties of egg whites. Because of such specific functional properties, it is often difficult to replace some proteins. Sodium caseinate in powdered coffee whiteners has successfully resisted replacement because of its emulsification properties and stability to curdling in hot coffee. Nonetheless, soy protein is now used successfully in some frozen coffee whiteners; vulnerability of sodium caseinate in coffee whiteners is therefore greater than believed just a few years ago.

The properties of proteins can be altered extensively by processing, such as heat treatment, alcohol extraction, or enzyme treatment. This affords the possibility of selective processing to enhance or develop given functional properties. Texturization by extrusion or spinning into fibers are examples of selective processing to obtain a desired property. A better understanding of the physical and chemical properties of soybean proteins in the future will undoubtedly assist in making available a greater number of protein ingredients to cover a broad spectrum of functional properties.

Nutritional Properties

Nutritional properties of soybean proteins are less important than functional properties when the proteins are used solely to provide functionality, because in many such applications the level of protein employed is low. However, when the level of protein involved is a significant part of the diet, nutrition must receive more attention. Soybean proteins have a lower nutritional value than casein, primarily because methionine and cystine content are low. This deficiency can be corrected either by adding methionine or by blending soybean proteins with other proteins. Methionine fortification is used with infant formulas based on soybean protein isolates that are the major source of protein in the diet. Blending soybean protein with other proteins is done successfully with meat analogs. One product, for example, contains soybean, wheat, yeast, and egg protein and has a nutritional value nearly the same as that of casein. Blending proteins is also done in some high-protein breakfast cereals. Although nutrition is a factor to consider, it is not an insurmountable obstacle for soybean proteins in many applications. Because soybean proteins are used primarily as food ingredients and are often blended with other proteins, nutritional considerations of protein quality will mainly concern food processors rather than consumers.

Government Regulations

Composition of a large number of foods in the United States is regulated by standards of identity established under the Federal Food, Drug, and Cosmetic Act and enforced by the Food and Drug Administration. These standards limit or even exclude protein ingredients from a number of foods. For example, the standards for bread permit 0.5 percent of enzyme-active ground soybeans for bleaching purposes, plus an additional 3 percent of soy flour. In contrast, the standards for fruit juices exclude optional protein ingredients.

Composition of meat and poultry products is regulated by the Federal Meat and Poultry Inspection Program of USDA. Standards of identity or composition spell out the amounts and kinds of protein ingredients that may be used in processed meats. For example, it is permissible to add up to $3\frac{1}{2}$ percent of soy flour or soy protein concentrate but only 2 percent of protein isolate to cooked sausages. Nonetheless, these regulations are subject to change. Soy flour has been permitted in sausages for more than 40 years; concentrates were approved as additives in 1962, whereas isolates were allowed in 1964. Currently under consideration are regulations on the use of textured vegetable proteins in meat products (Mussman, 1974).

Although Government regulations may sometimes limit use of soybean proteins, they may also help to stimulate the development of markets. An example of the latter type is the approval in 1971 of textured vegetable proteins for use in the School Lunch Program by the Food and Nutrition Service of USDA. This action is responsible for the present size of the market for textured soybean proteins and provided the stimulus for a number of companies to begin manufacture of these new products. Because of greater competition in this field, it is likely that the quality of textured products will improve and that the variety of items available will increase.

Governmental activities in foreign food assistance programs have also had a positive impact on creating future markets for soybean proteins. These programs have resulted in the development of a number of blended foods such as CSM (corn-soy-milk) and WSB (wheat soy blend), which have provided markets for soy flours; perhaps more important, they have also supported extensive nutritional studies with humans that have shown the effectiveness of soy proteins in supplementing cereal proteins (Graham and Baertl, 1974).

Consumer Acceptance

Economics is a strong driving force in the future development of outlets for soybean proteins, but consumer acceptance can be an equally important hurdle that must be cleared for successful market growth. Many factors, such as appearance, flavor, texture, convenience, nutrition, selling price, and cultural background, influence the consumer's decision to buy a particular food. The influence of selling price was shown with beef-soy blends that sold well as long as beef sold $0.15 to $0.20 a pound higher than the blends; when the price differential decreased, blend sales also dropped. The drop in sales of beef-soy blends with declining beef prices indicates that consumers consider beef-soy blends less satisfactory than all beef. This judgment may be based on poor flavor or texture in the cooked product or on the belief that all-meat is better nutritionally than the blends. In the latter case, consumer education could be a factor to promote markets for soybean proteins in products where they are readily identified as major ingredients.

On the other hand, consumer acceptance of soybean proteins is of less importance in foods where they are not a major ingredient (providing that they do not affect flavor or texture adversely). The words "soy" or "soybean" rarely are associated with the name of a product (except for items such as soy sauce), and frequently it is only on careful reading of the ingredient list that it becomes apparent that soybean proteins are one of the components. In products such as breakfast bars, high-protein cereals, etc., convenience and nutrition may be stressed instead.

Greater concern with nutrition by the consumer may also be important in increasing markets for soybean protein products. One company presently is promoting the fact that their meat analogs are free of animal fat and cholesterol. These products provide a greater variety of foods for consumers interested in limiting their intake of animal fats and cholesterol. Increased sales of margarine and lowfat milks in recent years suggest that a sizable portion of the population is exercising some control over their diets.

Advertising can be an important factor in influencing consumer acceptance of soybean protein products. Informative advertising that gives the consumer a clear picture of the advantages and values of such products could have a positive effect on stimulating consumer acceptance and demand. It has been suggested that such an advertising effort be supported and promoted on an industrywide basis rather than by individual companies (Schultz, 1974).

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MARKET POTENTIAL FOR SOY PROTEIN PRODUCTS

By William W. Gallimore
Economic Research Service

The high protein content of soy products is well known, but undesirable flavors, flatus (gas generated in the intestinal system), and problems with color and texture in some uses has limited the growth of its use in edible foods. Although consumer's tastes change slowly, more soy is being used as processing technology improves and other food proteins increase in price.

Actual data are not available on the manufacture of soy products, except edible flour and grits for 1973 and 1974. Estimates of soy production for selected years are given in table 21. All estimates were derived from contacts with industry, but without the estimator having access to actual production figures. Estimated production of flour and grits nearly doubled from 1967 to 1973; however, because industrial flour production was included for 1970, it is impossible to discuss changes in edible flour production from 1967 to 1970 or 1970 to 1973. Production of concentrates increased during the period, with the greater increase from 1970 to 1973. Production of isolates appears to have remained stable during 1967–73. No estimates are given of the production of textured products in 1967. Production of about 30 million pounds in 1970 more than tripled by 1973, making textured products the fastest growing of all products.

Table 21—Estimated U.S. manufacture of soy products, 1967, 1970, and 1973[1]

Soy protein food	1967	1970	1973
	Million pounds		
Flour and grits	305-371	[2] 500-600	[3] 575
Concentrates	17-30	35	50
Isolates	22-35	20-25	20-25
Textured items (extruded and spun)	......	30	100

[1] Source for 1967, Food Uses of Soy Protein, by Cleveland P. Eley, U.S. Dept. Agr., Econ. Res. Serv., ERS-388, Aug. 1968. Source for 1970, Substitutes and Synthetics for Agricultural Products, Projections for 1980, by William Gallimore, U.S. Dept. Agr., Mktg. Res. Rpt. 947, Mar. 1972. Source for 1973, Industry sources, Aug. 1974.

[2] Estimates of flour and grits for 1970 includes flour for industrial use, including pet foods in addition to flour used for edible purposes.

[3] Estimate of edible flour only.

Quarterly production of edible soy flour for the 1973 and 1974 crop years is shown in table 22. These data show a sizable increase in edible flour production, starting with the first quarter of 1974 and reaching more than 168 million pounds the second quarter of 1974, and then dropping slightly in the third quarter. This period generally coincided with high beef prices and the introduction of the soy-beef blends in grocery stores. As beef prices decreased, sale of the soy-beef blends declined and probably accounted, in part, for the decline of edible flour production in the third quarter of 1974. Fourth quarter production in 1974 was the same as the fourth quarter of 1973. The decrease in the fourth quarter for

Table 22—Production of edible soy flour, 1973/74 crop year deliveries[1]

Year and type of flour	Quarters				Total for year
	1	2	3	4	
			1,000 pounds		
1973:					
Total edible[2]	135,666	135,315	142,440	127,197	540,618
Total industrial[2]	73,360	75,404	68,646	65,570	282,980
Total deliveries[2]	209,026	210,719	211,086	192,767	823,598
1974:					
Total edible[2]	152,088	168,319	149,197	126,883	596,487
Total industrial[2]	82,546	79,684	64,306	64,185	290,721
Total deliveries[2]	234,634	248,003	213,503	191,068	887,208

[1] Data supplied by the Food Protein Council, Washington, D. C. First quarter of the crop year is October, November, and December of the previous calendar year.

[2] Includes exports.

both years probably reflects the drop in demand during the summer months when schools are closed. Edible soy flour production in the 1973–74 crop year accounted for about 3.0 percent of total domestic meal output.

Soy Proteins as Meat Substitutes

Soy proteins have been highly publicized as meat substitutes. The press features new products and many producers of soy products may have felt the demand for soy proteins unlimited. The market for soy proteins has grown and potential for growth still exists; however, demand is not unlimited and growth depends on the relative price of soy and meat products, quality of soy products, changes in State and Federal labeling regulations, and rapidity of change in consumer tastes. At present, we do not know the effect of most factors influencing use of edible soy proteins but there is fragmented information on the acceptance of some soy products.

A low, medium, and high level of market penetration of soy products for red meats was established for 1980 (Gallimore). Growth of substitutes was anticipated mainly in processed meats, with estimates of market penetration reflecting a sum of different rates of substitution for individual products, depending on each product and its market. Soy is likely to be substituted in products that are highly seasoned and use a variety of meats; also, soy proteins are combined with meat and nonmeat products or a product such as ground beef that may be used by consumers in conjunction with other foods or ingredients.

The medium estimate was that 16 percent of projected consumption of processed meat in 1980 would be replaced by soy proteins. This would represent more than 6 percent of red meat production and would require about 1,100 million pounds of soy flour. This is almost double the total production of 596 million pounds of edible soy flour produced in crop year 1974. Unless there is a dramatic increase in the use of soy extenders, it is unlikely this medium projection of market penetration by meat substitutes will be achieved in the next 5 years.

Institutional Markets.—Institutions buy more soy products than individual consumers do and they will probably continue as the major market for soy proteins for some time. The School Lunch Program; State and Federal institutions, such as hospitals and prisons; and to a lesser extent, colleges and other private institutions have used soy meat extenders and meat analogs. Institutions with fixed operational budgets and under pressure of rising costs have made the most extensive use of soy proteins. The lower cost of soy proteins has been largely responsible for the increased substitution of soy products for meat.

Institutions generally combine soy proteins with ground beef, although simulated chicken and beef chunks substitute as complete meats in some menus. Public restaurants, including fast food outlets, use limited quantities of soy in combination with other meats. Fast food outlets will probably be a faster growing market for soy products than conventional restaurants.

Collectively, schools participating in the Federal School Lunch Program are probably the largest domestic market for soy products. In 1971, USDA's Food and Nutrition Service released a special specification making hydrated vegetable protein allowable for reimbursement as a meat alternate. In the current program, textured soy proteins may be mixed with meat, poultry, or fish up to a maximum of 30 percent hydrated soy protein. The following estimates are for vegetable protein (mostly soy) sold to schools (Bird):

School Year	*Million Pounds Dry Weight*
1971–72	9
1972–73	19
1973–74	24

These are only estimates, but schools have made vegetable proteins a major food source in their feeding program. In October 1974, 35 companies produced or distributed textured products meeting requirements for inclusion in the School Lunch Program. Fourteen firms produced or distributed acceptable textured protein product mixes for sloppy joes, meatloaf, taco filling, spaghetti sauce, chili, meatballs, pizza, patties, and other products. The School Lunch Program will probably continue as the major user of soy proteins, primarily because of the need to keep cost low and cost savings can be achieved by substituting soy for animal proteins.

Mass Consumer Markets.—Until the past 3 or 4 years, meat substitutes had not been developed for the mass consumer market. With few exceptions, development and sales had been aimed at specially motivated groups, such as vegetarians or people desiring to restrict their intake of animal fats. Even now, meat analogs currently under development or in distribution will probably find their initial acceptance in these specifically motivated groups.

Products intended as extenders for meat, fish, and poultry have the greatest sales potential. Many products currently supplying the institutional market would be packaged for retail sale if there was sufficient demand. However, products are being developed specifically for sale through retail stores to consumers.

Soy-beef blends introduced in grocery stores in March 1973 have already achieved considerable success and have demonstrated the sales potential for soy products under certain conditions. These blends were 25-percent rehydrated soy and 75-percent ground beef and were premixed, packaged, handled, and displayed by the stores in the same manner as ground beef. High ground beef prices preceded the introduction of these blends, creating a favorable climate for their sales. Sales of the blends were observed in three grocery chains for a 46-week period beginning in May 1973 and ending in March 1974. Blend market shares expressed as a percent of total ground beef sales are shown in figure 14. Monthly market share for the blends generally declined from about 28 to just above 20 percent during the 36-week period. The blends averaged 19 cents per pound less than regular ground beef for the period. These data show consumers will buy a soy-extended product if the quality is acceptable and price sufficiently lower than the competing meat product. Total blend sales were estimated at 175 million pounds from July 1973 to June 1974—equivalent to about 15 million pounds of soy products, dry weight.

The first blends were mixed in central plants owned by the store or at the individual stores and not frozen. Currently, blends on the market are packed by independent meat packers and sold frozen in patties or packs.

Success of the premixed soy-beef blends spawned introduction in grocery stores of a number of dry soy products designed for home mixing by consumers. These products ranged from uncolored, unflavored soy products to preseasoned mixes for meatloaf, pizza, meatballs, and other products. Data are not available on quantities sold, but trade publications indicate they met with only limited success. Casserole-type dishes containing soy products are available in grocery stores and offer potential for expanding sale of soy proteins to consumers.

Soy Proteins As Dairy Substitutes

Substitutes such as margarine and whipped toppings have captured much of the butter and light cream markets. Filled and synthetic milks achieved limited success in replacing fluid milk in selected markets in the late 1960's, so substitutes are not new to the dairy industry. Potential for substituting soy proteins exists in three classes of products: nonfat dry milk, fluid milk, and cheese analogs or extenders.

Nonfat dry milk replacers offer growth potential for soy proteins in dairy substitutes. The average wholesale price of nonfat dry milk was 33 cents per pound in September 1972, compared with 57 cents in September 1974. In 1973, demand by food processors for nonfat dry milk was such that prices increased above previous levels and import quotas were changed in 1973 to allow imports of nonfat dry milk. But imports were not available until late 1973 and early 1974.

Wholesale prices increased from 39 cents per pound in January 1973 to 54 cents per pound in January 1974 and then to 67 cents in April 1974. Since June 1974, prices have held at just above the support level of 57 cents per pound. Through October 1974, the Government purchased about 196 million pounds of nonfat dry milk through Commodity Credit

Corporation and as of October, held 135 million pounds in uncommitted inventories. Present demand suggests food processors and other users turned to whey, whey-soy mixtures, or whey mixed with other proteins as replacers for nonfat dry milk during the rapid rise in prices during 1973 and 1974. The exports arrived after the support price had been increased due to rising costs so that supply exceeds the demand at current support levels. The experience of the citrus and cotton textile industries in losing markets indicates that the dairy industry may have difficulty in recapturing markets for nonfat dry milk that have been lost to nonfat milk replacers. In fact, substitutes may gain an increased share of the nonfat milk market.

A number of cheese substitutes are on the market and new ones are currently being developed. These are intended primarily as replacements for cheese in pizza and other cooked dishes. They may be used alone or in conjunction with natural cheese.

Cheese substitutes have received approval for use in the Federal School Lunch Program. They may be used as a cheese alternate, but must be mixed in equal proportions with natural cheese and are permitted only in cooked products. The cheese substitutes must have the same nutritional qualities as natural cheese for acceptance in the program.

It is too early to forecast the demand for soy protein in this market. Some imitation cheeses have no soy protein in their formulations. The total market for imitation cheeses is expected to grow and undoubtedly soy products will form part of the ingredients used.

Soy Proteins in Baked Goods

Baked goods have been a steady and increasing market for soy products, especially flour. Eley estimated that about 50 million pounds of soy flour was used in baked goods in 1967 and estimated industry growth at 5 to 10 percent annually. One private source estimated that slightly more than 100 million pounds of soy flour was used in baked goods in 1973, indicating a growth rate of more than 10 percent. Yet, soy flour can have an adverse effect on baking qualities of bread and other baked goods if not properly processed and treated. New technology has eliminated many of these adverse effects and soy flour and other soy products may gain wider acceptance in the baking industry, not only for these functional qualities but also because they improve nutrition.

Soy Proteins in Foreign Feeding Programs

Soy flour composes part of many commodities such as soy fortified bulgur, soy fortified bread flour, corn-soy milk, corn-soy blend, and wheat-soy blend used in the foreign feeding programs. Soy specifically supplies protein fortification to improve nutrition of the foods. It is estimated that about 644 million pounds of products containing soy flour were distributed under P.L. 480, Title II, in fiscal 1974, representing about 135 million pounds of soy flour, one of the major uses of edible soy flour in the world (Crowley). Corn soy blend, the major use, took an estimated 44 million pounds of soy flour in fiscal 1974.

Low cost, good nutrition, and functional versatility account for the ever-increasing quantities of soy proteins in food programs in less developed countries. Soy flour is the major ingredient in blended foods with flour and grits added to corn, sorghum, and oat products distributed overseas. Whey-soy drink mix is a new product recently added to the list of commodities available for distribution in feeding programs. It was developed as a replacement for dry milk in the feeding program when the price of dry milk increased dramatically in 1973. The finished product, 41.4 percent sweet whey, 36.5 percent full fat soybean flour, 12.1 percent soybean oil, and 9.5 percent corn sugar when mixed with water at 15 percent solids provides a drink with nearly the same energy and protein content as whole milk. Considering present and projected needs, increased quantities of soy proteins will be needed to supply feeding programs under P.L. 480, Title II.

Literature Cited

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Gallimore, W. W. 1972. Synthetics and Substitutes for Agricultural Products, Projections for 1980, U.S. Dept. Agr. Mktg. Res. Rpt. 947, Mar.

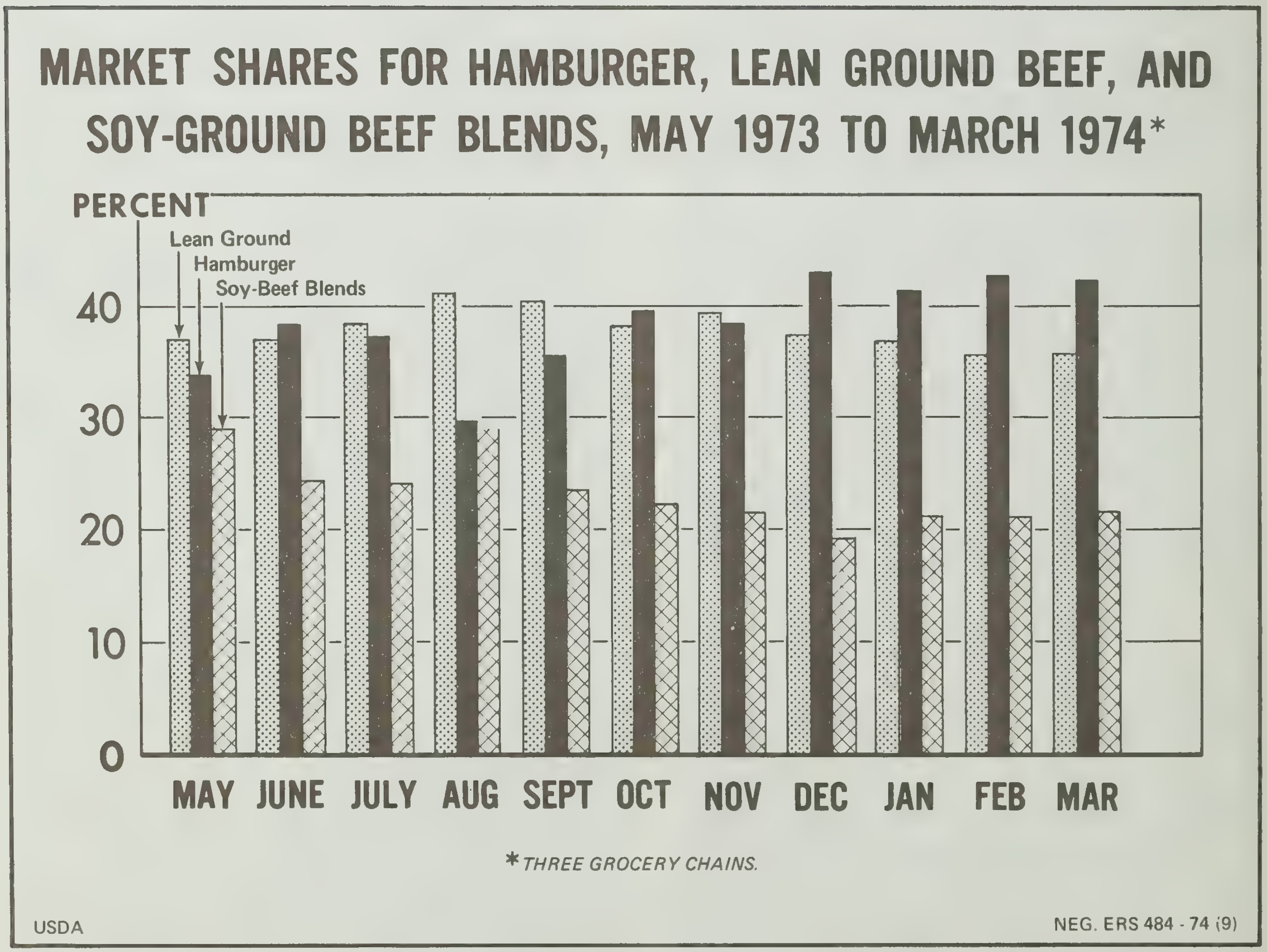
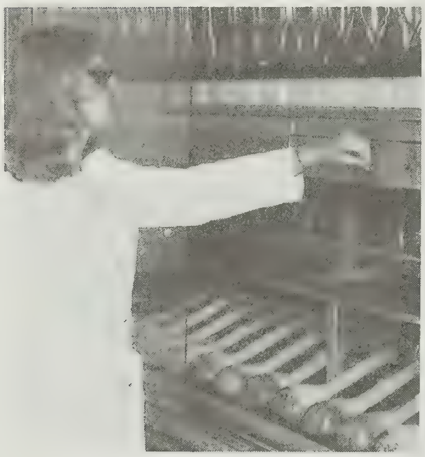
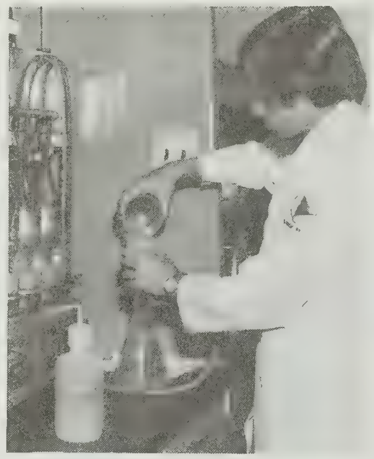


Figure 14. — Comparison of hamburger, lean ground beef and soy-ground beef blends.

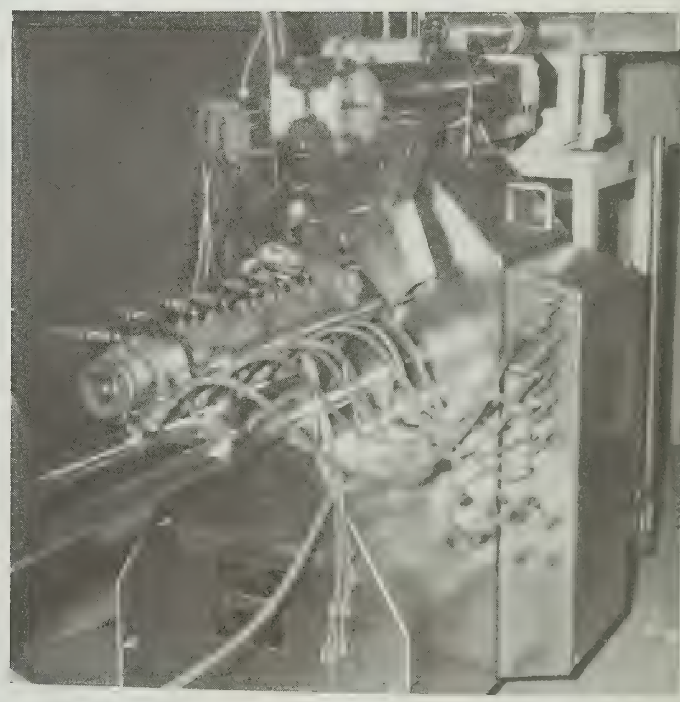
David Hammond, soy specialities superintendent, studies soy speciality plant model used for planning and construction of Dawson Mills plant, below.





Owen Olesen, bacteriologist, runs a test in the Dawson Mills laboratory, while chemist Nancy Boese performs protein testing. Owen Olesen works with fiber analysis equipment. Chemists Steve Owen and Tim Maus are engaged in product development experiments.

Pilot size extruder located in laboratory.



APPENDIX — COMPANIES PRODUCING AND DISTRIBUTING SOY PRODUCTS

UNITED STATES DEPARTMENT OF AGRICULTURE
FOOD AND NUTRITION SERVICE

WASHINGTON D.C. 20250

THIS LISTING IS EFFECTIVE ONLY UNTIL THE NEW REGULATIONS GOVERNING A REFORMULATED TEXTURED VEGETABLE PROTEIN PRODUCT ARE FINALIZED AND PUT INTO EFFECT, AND UNTIL A LISTING OF THE NEW REFORMULATED PRODUCTS IS ISSUED.

September 1974
(6th Revision)

I. Companies Producing and/or Distributing Under Private Label Brands of Textured Vegetable Protein Products that Meet the Requirements of FNS Notice 219

Note: The textured vegetable protein products listed on the following pages may be "textured vegetable proteins," 1/ "concentrates," "isolates" or mixtures. "Textured vegetable proteins" contain from 50 to 55 percent protein on a dry basis. "Concentrates" contain about 70 percent protein. "Isolates" contain from about 90 to 94 percent protein. The mixtures can range from 50 to 70 percent protein. All products are either dry or hydrated. The hydrated products are identified on the list. All others are dry products.

COMPANY	PRODUCT	COLOR	FLAVOR
Allen Foods, Inc. 8543 Page Avenue St. Louis, Missouri 63114	LASCO Fortified, Unflavored Textured Vegetable Protein, 2105 Extender for Beef (identical to NUTRA-MATE 2105 manufactured by A.E. Staley)	dark	unflavored
	LASCO Fortified, Unflavored Textured Vegetable Protein, 2100 Extender for Fish and Poultry (identical to NUTRA-MATE 2100 manufactured by A. E. Staley)	light	unflavored
Archer Daniels Midland Company Box 1470 Decatur, Illinois 62525	TVP Textured Vegetable Protein, unflavored, shredded, fortified	natural	unflavored

1/ Although we use the term "textured vegetable protein products" as a general term to describe all four groups of products, the industry commonly uses this term to describe products containing 50 to 55 percent protein.

COMPANY	PRODUCT	COLOR	FLAVOR
Archer Daniels Midland Company (continued)	TVP Textured Vegetable Protein, unflavored, color C, shredded, fortified	caramel	unflavored
	TVP Textured Vegetable Protein, unflavored, minced 180, fortified	natural	unflavored
	TVP Textured Vegetable Protein, unflavored, color C, minced 180, fortified	caramel	unflavored
	TVP Textured Vegetable Protein, flavor like beef, minced 240, fortified	caramel	beef
	TVP Textured Vegetable Protein, flavor like ham, minced 240, fortified	colored	ham
	TVP Textured Vegetable Protein, unflavored, chunks #10, fortified	natural	unflavored
	TVP Textured Vegetable Protein, flavor like beef, chunks #10, fortified	caramel	beef
	TVP Textured Vegetable Protein, flavor like ham, chunks #10, fortified	colored	ham
Biggers Brothers, Inc. P. O. Box 2356 2800 South Boulevard Charlotte, North Carolina 28201	FARMBEST PROMATE 100 SL Textured Vegetable Protein (identical to PROMATE 100 SL manufactured by Griffith)	caramel	unflavored
	FARMBEST PROMATE 111 SL Textured Vegetable Protein (identical to PROMATE 111 SL manufactured by Griffith)	uncolored	unflavored
Cargill, Incorporated Soy Protein Products Dept. Cargill Building Minneapolis, MN 55402	TEXTRATEIN Minced #18F	uncolored	unflavored
	TEXTRATEIN Minced #18BF	caramel	unflavored
	TEXTRATEIN Minced #50F	uncolored	unflavored
	TEXTRATEIN Minced #50BF	caramel	unflavored
	TEXTRATEIN #12 Chunk F	uncolored	unflavored
	TEXTRATEIN #12 Chunk BF	caramel	unflavored

COMPANY	PRODUCT	COLOR	FLAVOR
Central Soya Company, Inc. 1825 North Laramie Chicago, Illinois 60639	PROMOSOY-SL Soy Protein Concentrate Granular	natural tan	unflavored
	CENTEX - 300 SL Textured Soy Flour	natural tan	unflavored
	CENTEX - 400 SL Textured Soy Flour	caramel	unflavored
	CENTEX - 500 SL Textured Soy Flour	natural tan	unflavored
	CENTEX - 600 SL Textured Soy Flour	caramel	unflavored
Continental Coffee Company 2550 North Clybourn Avenue Chicago, Illinois 60614	CONTINENTAL Fortified, Unflavored Textured Vegetable Protein, Extender for Beef (identical to NUTRA-MATE 2105 manufactured by A. E. Staley)	dark	unflavored
	CONTINENTAL Fortified, Unflavored Textured Vegetable Protein, Extender for Fish and Poultry (identical to NUTRA-MATE 2100 manufactured by A. E. Staley)	light	unflavored
Continental Organization of Distributor Enterprises, Inc. Suite 602 Manor Oak Two 1910 Cochran Road Pittsburgh, Pennsylvania 15220	CODE Fortified, Unflavored Textured Vegetable Protein, 2105 Extender for Beef (identical to NUTRA-MATE 2105 manufactured by A. E. Staley)	dark	unflavored
	CODE Fortified, Unflavored Textured Vegetable Protein, 2100 Extender for Fish and Poultry (identical to NUTRA-MATE 2100 manufactured by A.E. Staley)	light	unflavored
	CODE PROMATE 100 SL Textured Vegetable Protein (identical to PROMATE 100 SL manufactured by Griffith)	caramel	unflavored
	CODE PROMATE 111 SL Textured Vegetable Protein (identical to PROMATE 111 SL manufactured by Griffith)	uncolored	unflavored

COMPANY	PRODUCT	COLOR	FLAVOR
Embassy Grocery Corporation 57-10 49th Street Maspeth, New York 11378	EMBASSY's LUCKY BOY PRO-TENDA, 2105 Textured Vegetable Protein, Fortified (identical to NUTRA-MATE 2105 manufactured by A. E. Staley)	dark	unflavored
	EMBASSY's LUCKY BOY PRO-TENDA, 2100 Textured Vegetable Protein, Fortified (identical to NUTRA-MATE 2100 manufactured by A.E. Staley)	light	unflavored
Far-Mar-Co., Inc. 960 North Halstead Hutchinson, Kansas 67501	ULTRA-SOY Chunks #1, neutral (F)	neutral	unflavored
	ULTRA-SOY Chunks #1, caramel colored (F)	caramel	unflavored
	ULTRA-SOY Chiplets, neutral (F)	neutral	unflavored
	ULTRA-SOY Chiplets, caramel colored (F)	caramel	unflavored
	ULTRA-SOY 100's, neutral (F)	neutral	unflavored
	ULTRA-SOY 100's, caramel colored (F)	caramel	unflavored
	ULTRA-SOY 200's, neutral (F)	neutral	unflavored
	ULTRA-SOY 200's, caramel colored (F)	caramel	unflavored
	ULTRA-SOY Minced, neutral (F)	neutral	unflavored
	ULTRA-SOY Minced, caramel colored (F)	caramel	unflavored
	ULTRA-SOY Chunks #10, neutral (F)	neutral	unflavored
	ULTRA-SOY Chunks #10, caramel colored (F)	caramel	unflavored
	ULTRA-SOY Chunks #20, neutral (F)	neutral	unflavored
	ULTRA-SOY Chunks #20, caramel colored (F)	caramel	unflavored
Federated Foods, Inc. 2250 East Devon Avenue Des Plaines, Illinois 60018	PARADE PROMATE 100 SL Textured Vegetable Protein (identical to PROMATE 100 SL manufactured by Griffith)	caramel	unflavored
	PARADE PROMATE 111 SL Textured Vegetable Protein (identical to PROMATE 111 SL manufactured by Griffith)	uncolored	unflavored
	RED & WHITE PROMATE 100 SL Textured Vegetable Protein (identical to PROMATE 100 SL manufactured by Griffith)	caramel	unflavored

COMPANY	PRODUCT	COLOR	FLAVOR
Federated Foods, Inc. (continued)	RED & WHITE PROMATE 111 SL Textured Vegetable Protein (identical to PROMATE 111 SL manufactured by Griffith)	uncolored	unflavored
First Spice Mixing Co., Inc. 33-33 Greenpoint Avenue Long Island City, N. Y. 11101	TEXITE 176 Textured Vegetable Protein Fortified (identical to TVP Textured Vegetable Protein, minced 180, fortified, manufactured by Archer Daniels Midland)	natural	unflavored
Frozen Food Forum, Inc. 120 W. Wieuca Road Atlanta, Georgia 30342	FROSTY ACRES 2105 Extender for Beef, Fortified Textured Vegetable Protein (identical to NUTRA-MATE 2105 manufactured by A. E. Staley)	dark	unflavored
	FROSTY ACRES 2100 Extender for Fish and Poultry, Fortified Textured Vegetable Protein (identical to NUTRA-MATE 2100 manufactured by A. E. Staley)	light	unflavored
Galanides, Inc. P. O. Box 168 1249 Wicker Drive Raleigh, North Carolina 27604	GALANIDES 2105 Textured Vegetable Protein, Fortified (identical to NUTRA-MATE 2105 manufactured by A. E. Staley)	dark	unflavored
	GALANIDES 2100 Textured Vegetable Protein, Fortified (identical to NUTRA-MATE 2100 manufactured by A. E. Staley)	light	unflavored
General Mills, Inc. 9200 Wayzata Blvd. Minneapolis, Minnesota 55440	Frozen Products (hydrated products)		
	BONTRAE Textured Vegetable Protein Product Crumbles with Flavor Like Beef	caramel	beef
	BONTRAE Textured Vegetable Protein Product Dice with Flavor Like Ham	colored	ham
	BONTRAE Vegetable Protein Product Chunks with Flavor Like Chicken	colored	chicken
	BONTRAE Textured Vegetable Protein Product Dice with Flavor Like Chicken	colored	chicken

COMPANY	PRODUCT	COLOR	FLAVOR
General Mills, Inc. (continued)	Dehydrated Products		
	BONTRAE Textured Vegetable Protein Product Crumbles with Flavor Like Beef	caramel	beef
	BONTRAE Textured Vegetable Protein Product Unflavored Crumbles with Color	caramel	unflavored
	BONTRAE Textured Vegetable Protein Product Unflavored Crumbles	uncolored	unflavored
	GENERAL MILLS Textured Vegetable Protein Product Crumbles with a Flavor Like Beef	caramel	beef
	GENERAL MILLS Textured Vegetable Protein Product Unflavored Crumbles with Color	caramel	unflavored
	GENERAL MILLS Textured Vegetable Protein Product Unflavored Crumbles	uncolored	unflavored
	GENERAL MILLS PROTEIN II Textured Vegetable Protein Flakes	uncolored	flavored
Griffith Laboratories 1415 West 37th Street Chicago, Illinois 60609	GRIFFITH's GL-219 Granular Soy Protein Concentrate	uncolored	unflavored
	GRIFFITH's PROMATE # 100 SL Textured Vegetable Protein	caramel	unflavored
	GRIFFITH's PROMATE # 111 SL Textured Vegetable Protein	uncolored	unflavored
	GRIFFITH's PROMATE # 500 SL Textured Vegetable Protein	caramel	unflavored
	GRIFFITH's PROMATE # 555 SL Textured Vegetable Protein	uncolored	unflavored
	GRIFFITH's GSVP 125 SL Structured Soy Flour	uncolored	unflavored
	GRIFFITH's GSVP 125C SL Structured Soy Flour	caramel	unflavored
	GRIFFITH's GSVP 150 SL Structured Soy Flour	uncolored	unflavored
	GRIFFITH's GSVP 150C SL Structured Soy Flour	caramel	unflavored

COMPANY	PRODUCT	COLOR	FLAVOR
Griffith Laboratories (continued)	GRIFFITH's GSPC 125 SL Textured Soy Protein Concentrate	uncolored	unflavored
	GRIFFITH's GSPC 125C SL Textured Soy Protein Concentrate	caramel	unflavored
	GRIFFITH's GSPC 150 SL Textured Soy Protein Concentrate	uncolored	unflavored
	GRIFFITH's GSPC 150C SL Textured Soy Protein Concentrate	caramel	unflavored
B. Heller & Company Calumet Avenue & 40th Street Chicago, Illinois 60653	HELLER's Textured Vegetable Protein #65 with Vitamin Supplement	neutral	unflavored
	HELLER's Textured Vegetable Protein #75 with Vitamin Supplement	caramel	unflavored
Hollymatic Corporation 80 North Street Park Forrest, Illinois 60466	HOLLYMATIC Soy Protein Concentrate S.P.C. 219 (identical to GL-219 manufactured by Griffith)	neutral	unflavored
Institutional Wholesalers, Inc. P. O. Box 4747 Liberty Church Road at Highway 247 North Macon, GA 31208	SAXONY Textured Vegetable Protein Fortified, Color C, Minced No. 180 (identical to TVP, minced 180, fortified, color C manufactured by Archer Daniels Midland)	caramel	unflavored
	SAXONY Textured Vegetable Protein, Fortified, Minced No. 180 (identical to TVP, minced 180, fortified manufactured by Archer Daniels Midland)	natural	unflavored
	SAXONY Textured Vegetable Protein Fortified, Color C, Minced No. 240, (identical to TVP, minced 240, fortified, color C manufactured by Archer Daniels Midland)	caramel	unflavored
	SAXONY Textured Vegetable Protein, Fortified, Minced No. 240 (identical to TVP, minced 240, fortified manufactured by Archer Daniels Midland)	natural	unflavored

COMPANY	PRODUCT	COLOR	FLAVOR
Lauhoff Grain Company, Inc. 321 East North Street Danville, IL 61832	VITA-PRO 100 or XVP 100	colored	unflavored
	VITA-PRO 111 or XVP 111	uncolored	unflavored
	VITA-PRO 100CS or XVP 100CS	colored	unflavored
	VITA-PRO 555 or XVP 555	uncolored	unflavored
	VITA-PRO 500 or XVP 500	colored	unflavored
Marshall Produce Company Division of Marshall Foods, Inc. Marshall, MN 56258	MARSHALL Textured Vegetable Protein MARTEX, Code 910 (identical to TEXTRATEIN minced #18F manufactured by Cargill)	uncolored	unflavored
	MARSHALL Textured Vegetable Protein MARTEX, Code 915 (identical to TEXTRATEIN minced #18 BF manufactured by Cargill)	caramel	unflavored
Miles Laboratories Elkhart, IN 46514	MILES MAXTEN-C, a Textured Vegetable Protein Product	caramel	unflavored
	MILES MAXTEN-U, a Textured Vegetable Protein Product	uncolored	unflavored
	TEMPTEIN BEEF-LIKE FLAVORED GRANULES, a Spun Vegetable Protein Product	caramel	beef
	TEMPTEIN MEAT-LIKE NUGGETS, an Unflavored Spun Vegetable Protein Product	caramel	unflavored
Nabisco, Inc. Protein Foods Division 425 Park Avenue New York City, NY 10022	VMR I Fortified Textured Vegetable Protein, Size 516	caramel or uncolored	unflavored or flavored
	VMR I Fortified Textured Vegetable Protein, Size 500	caramel or uncolored	unflavored or flavored
	VMR I Fortified Textured Vegetable Protein, Size 816	caramel or uncolored	unflavored or flavored
	VMR I Fortified Textured Vegetable Protein, Size 1600	caramel or uncolored	unflavored or flavored
	VMR II Fortified Textured Vegetable Protein, Size 1418	caramel or uncolored	unflavored or flavored
	VMR II Fortified Textured Vegetable Protein, Size 3814	caramel or uncolored	unflavored or flavored

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COMPANY	PRODUCT	COLOR	FLAVOR
Nabisco, Inc. (continued)	VMR III Fortified Textured Vegetable Protein, Coarse	caramel or uncolored	unflavored or flavored
	VMR III Fortified Textured Vegetable Protein, Size 600	caramel or uncolored	unflavored or flavored
National Institutional Food Distributor Associates, Inc. Box 19936, Station N Atlanta, GA 30325	NIFDA PROMATE 100SL Textured Vegetable Protein (identical to PROMATE 100SL manufactured by Griffith)	caramel	unflavored
	NIFDA PROMATE 111SL Textured Vegetable Protein (identical to PROMATE 111SL manufactured by Griffith)	uncolored	unflavored
National Protein Corporation 4830 S. Christiana Avenue Chicago, IL 60632	TEXTRASOY-412 FC Textured Vegetable Protein	caramel	unflavored
	TEXTRASOY-412 F Textured Vegetable Protein	uncolored	unflavored
National School-Pak 1415 West 37th Street Chicago, IL 60609	NATIONAL SCHOOL-PAK PROMATE 100 SL Textured Vegetable Protein (identical to PROMATE 100 SL manufactured by Griffith)	caramel	unflavored
	NATIONAL SCHOOL-PAK PROMATE 111 SL Textured Vegetable Protein (identical to PROMATE 111 SL manufactured by Griffith)	uncolored	unflavored
Nugget Distributors, Inc. P. O. Box 8309 Stockton, CA 95204	NUGGET PROMATE 100 SL Textured Vegetable Protein (identical to PROMATE 100 SL manufactured by Griffith)	caramel	unflavored
	NUGGET PROMATE 111 SL Textured Vegetable Protein (identical to PROMATE 111 SL manufactured by Griffith)	uncolored	unflavored
	NUGGET MAGI-PRO Fortified, Unflavored Textured Vegetable Protein, 2105 (identical to NUTRA-MATE 2105 manufactured by A. E. Staley)	dark	unflavored
	NUGGET MAGI-PRO Fortified, Unflavored Textured Vegetable Protein, 2100 (identical to NUTRA-MATE 2100 manufactured by A. E. Staley)	light	unflavored

COMPANY	PRODUCT	COLOR	FLAVOR
Oppenheimer Casing Co. 1020 West 36th St. Chicago, Illinois 60609	TEXTURED OPPENHEIMER PRO 110 Textured Vegetable Protein (identical to MIRA-TEX 210-F manufactured by A. E. Staley)	uncolored	unflavored
	TEXTURED OPPENHEIMER PRO 110-C Textured Vegetable Protein (identical to MIRA-TEX 210-2-F manufactured by A. E. Staley)	caramel	unflavored
Portland Wholesale Grocery Co. 3939 S.E. 26th Avenue Portland, Oregon 97207	PREFERRED STOCK Fortified, Unflavored Textured Vegetable Protein, Extender for Beef 2105 (identical to NUTRA-MATE 2105 manufactured by A. E. Staley)	dark	unflavored
	PREFERRED STOCK Fortified, Unflavored Textured Vegetable Protein, Extender for Poultry and Seafood 2100 (identical to NUTRA-MATE 2100 manufactured by A. E. Staley)	light	unflavored
Ralcon Foods 2 North Riverside Plaza Chicago, Illinois 60606	SPF-200-Fortified (hydrated product)	natural	unflavored
Ralston Purina Company Checkerboard Square St. Louis, Missouri 63188	SUPRO 50A-1F Textured Vegetable Protein	caramel	unflavored
	SUPRO 50A-2F Textured Vegetable Protein	uncolored	unflavored
	SUPRO 50A-3F Textured Vegetable Protein	caramel	unflavored
	SUPRO 50A-4F Textured Vegetable Protein	uncolored	unflavored
	SUPRO 50-1F Textured Vegetable Protein	caramel	unflavored
	SUPRO 50-2F Textured Vegetable Protein	uncolored	unflavored
	SUPRO 50-3F Textured Vegetable Protein	caramel	unflavored
	SUPRO 50-4F Textured Vegetable Protein	uncolored	unflavored
S. E. Rykoff & Company 761 Terminal Street Los Angeles, CA 90021	S.E.R. Unflavored, Fortified PRO-TEAM Caramel Colored Textured Vegetable Protein, 2105 Extender for Beef (identical to NUTRA-MATE 2105 manufactured by A. E. Staley)	caramel	unflavored

COMPANY	PRODUCT	COLOR	FLAVOR
S. E. Rykoff & Company (continued)	S.E.R. Unflavored, Fortified PRO-TEAM White Textured Vegetable Protein, 2100 Extender for Fish and Poultry (identical to NUTRA-MATE 2100 manufactured by A. E. Staley)	white	unflavored
	S.E.R. Unflavored, Caramel Colored, Fortified PRO-TEAM Textured Vegetable Protein, minced 180 (identical to TVP, minced 180, fortified, color C manufactured by Archer Daniels Midland)	caramel	unflavored
	S.E.R. Unflavored, White, Fortified PRO-TEAM Textured Vegetable Protein, minced 180 (identical to TVP, minced 180, fortified manufactured by Archer Daniels Midland)	white	unflavored
John Sexton & Company P. O. Box JS Chicago, Illinois 60690	SEXTON PROTEIN-PLUS Textured Vegetable Protein	caramel	unflavored
	SEXTON PROTEIN-PLUS FLAKES Textured Vegetable Protein	uncolored	unflavored
A. E. Staley Mfg. Company Food Service Division 2011 Swift Drive Oak Brook, Illinois 60521	NUTRA-MATE Fortified, Unflavored Textured Vegetable Protein 2100	light	unflavored
	NUTRA-MATE Fortified, Unflavored Textured Vegetable Protein 2105	dark	unflavored
	NUTRA-MATE Fortified, Unflavored Textured Vegetable Protein 2410F	light	unflavored
A. E. Staley Mfg. Company Protein Division 2200 Eldorado Street Decatur, Illinois 62525	MIRA-TEX 200-F Textured Vegetable Protein	uncolored	unflavored
	MIRA-TEX 200-F (2H) Textured Vegetable Protein	uncolored	flavored
	MIRA-TEX 210-F Textured Vegetable Protein	uncolored	unflavored
	MIRA-TEX 210-F (2) Textured Vegetable Protein	uncolored	unflavored
	MIRA-TEX 210-1-F Textured Vegetable Protein	caramel	unflavored
	MIRA-TEX 210-1-F (2) Textured Vegetable Protein	caramel	unflavored
	MIRA-TEX 210-2-F Textured Vegetable Protein	caramel	unflavored
	MIRA-TEX 220-F Textured Vegetable Protein	uncolored	unflavored

COMPANY	PRODUCT	COLOR	FLAVOR
A. E. Staley Mfg. Co. Protein Division (continued)	MIRA-TEX 220-1-F Textured Vegetable Protein	caramel	unflavored
	MIRA-TEX 220-2-F Textured Vegetable Protein	caramel	unflavored
	MIRA-TEX 230-F Textured Vegetable Protein	uncolored	unflavored
	MIRA-TEX 230-1-F Textured Vegetable Protein	caramel	unflavored
	MIRA-TEX 230-2-F Textured Vegetable Protein	caramel	unflavored
	MIRA-TEX 240-F Textured Vegetable Protein	uncolored	unflavored
	MIRA-TEX 400-F Textured Vegetable Protein	uncolored	unflavored
	MIRA-TEX 400-11-F Textured Vegetable Protein	caramel	unflavored
	MIRA-TEX 405-F Textured Vegetable Protein	uncolored	unflavored
	MIRA-TEX 405-F(2) Textured Vegetable Protein	uncolored	unflavored
	MIRA-TEX 405-11-F Textured Vegetable Protein	caramel	unflavored
	MIRA-TEX 410-F Textured Vegetable Protein	uncolored	unflavored
	MIRA-TEX 410-11-F Textured Vegetable Protein	caramel	unflavored
Swift Edible Oil Company 115 West Jackson Boulevard Chicago, Illinois 60604	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:10000 TA	uncolored	unflavored
	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:10100 TA	uncolored	unflavored
	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:10107 TA	uncolored	flavored
	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:10300 TA	uncolored	unflavored
	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:10307 TA	uncolored	flavored
	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:10407 TA	uncolored	flavored
	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:10900 TA	uncolored	unflavored

COMPANY	PRODUCT	COLOR	FLAVOR
Swift Edible Oil Company (continued)	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:10907 TA	uncolored	flavored
	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:52000 TA	caramel	unflavored
	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:52000-D TA	caramel	unflavored
	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:52300 TA	caramel	unflavored
	SWIFT's TEXGRAN BRAND Textured Vegetable Protein Code:52400 TA	caramel	unflavored
	SWIFT's SFP-TA	uncolored	unflavored
	SWIFT's BURGER-AIDE I	uncolored	beef
Sysco Corporation Capital National Bank Bldg. 1300 Main Street, Suite 800 Houston, Texas 77002	SYSCO Fortified, Unflavored Textured Vegetable Protein for Use with Fish and Poultry, 2100 (identical to NUTRA-MATE 2100 manufactured by A. E. Staley)	light	unflavored
	SYSCO PROMATE 100SL Textured Vegetable Protein (identical to PROMATE 100SL manufactured by Griffith)	caramel	unflavored
	SYSCO PROMATE 111SL Textured Vegetable Protein (identical to PROMATE 111SL manufactured by Griffith)	uncolored	unflavored
	SYSCO Fortified, Unflavored Textured Vegetable Protein for Use with Meat, 2105 (identical to NUTRA-MATE 2105 manufactured by A. E. Staley)	dark	unflavored

Since the September 1974 listing of acceptable textured vegetable protein products (6th revision) was released, we have examined analyses of the following textured vegetable protein products and find them acceptable under FNS Notice 219 for use in the Child Nutrition Programs.

COMPANY	PRODUCT	COLOR	FLAVOR
Custom Food Products, Inc. 3127 W. Chicago Avenue Chicago, IL 60622	CFP Textured Vegetable Protein, Coarse, Plain (identical to VITA-PRO 555 manufactured by Lauhoff Grain Company)	Uncolored	Unflavored
	CFP Textured Vegetable Protein, Coarse, Colored (identical to VITA-PRO 500 manufactured by Lauhoff Grain Company)	Colored	Unflavored
	CFP Textured Vegetable Protein, Medium, Plain (identical to VITA-PRO 111 manufactured by Lauhoff Grain Company)	Uncolored	Unflavored
	CFP Textured Vegetable Protein, Medium, Colored (identical to VITA-PRO 100 manufactured by Lauhoff Grain Company)	Colored	Unflavored
Miles Laboratories, Inc. Elkhart, IN 46514	PRO-LEAN-CF, a Textured Vegetable Protein Product	Caramel	Unflavored
	PRO-LEAN-UF, a Textured Vegetable Protein Product	Uncolored	Unflavored
	PRO-LEAN-CF, a Textured Vegetable Protein Product with Spices and Seasonings	Caramel	Flavored
	PRO-LEAN-UF, a Textured Vegetable Protein Product with Spices and Seasonings	Uncolored	Flavored
Ralston Purina Company Checkerboard Square St. Louis, MO 63188	SUPRO 50-5F Textured Vegetable Protein	Caramel	Unflavored
	SUPRO 50-21F Textured Vegetable Protein	Caramel	Unflavored

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COMPANY	PRODUCT	COLOR	FLAVOR
Ralston Purina Company (Continued)	SUPRO 50A-6F Textured Vegetable Protein	Uncolored	Unflavored
Industrial Grain Products, Ltd. P. O. Box 6089 Montreal, Quebec H3C - 3H1 Canada	PERPLUS Code 9924 Textured Soy Flour-Wheat Gluten Blend, fortified	Natural	Unflavored
	PERPLUS Code 9936 Textured Soy Flour-Wheat Gluten Blend, fortified	Caramel	Unflavored
Archer Daniels Midland Co. Box 1470 Decatur, IL 62525	TVP Textured Vegetable Protein, flavor like beef, minced 180, fortified	Caramel	Beef flavor
	TVP Textured Vegetable Protein, unflavored, Color C, minced 240, fortified	Caramel	Unflavored
General Spice, Inc. 238 St. Nicholas Street South Plainfield, NJ 07080	SOTEX Textured Soy Flour F (identical to TVP, minced 180, fortified, manufactured by Archer Daniels Midland)	Uncolored	Unflavored
or 6338 Lambert Street Detroit, MI 48211	SOTEX Textured Soy Flour CF (identical to TVP, minced 180, fortified, Color C manufactured by Archer Daniels Midland)	Caramel	Unflavored
Custom Food Products, Inc. 3127 W. Chicago Avenue Chicago, IL 60622	CFP Textured Vegetable Protein, Medium-Plain 6175 (identical to TEXTRATEIN, Minced 18F, manufactured by Cargill)	Uncolored	Unflavored
	CFP Textured Vegetable Protein, Medium-Colored 6176 (identical to TEXTRATEIN, Minced 18BF, manufactured by Cargill)	Caramel	Unflavored
	CFP Textured Vegetable Protein, Coarse-Plain 6177 (identical to TEXTRATEIN, Minced 50F, manufactured by Cargill)	Uncolored	Unflavored

COMPANY	PRODUCT	COLOR	FLAVOR
Custom Food Products, Inc. (Continued)	CFP Textured Vegetable Protein, Coarse-Colored 6178 (identical to TEXTRATEIN, Minced 50BF, manufactured by Cargill)	Caramel	Unflavored
Cargill, Inc. Soy Protein Products Dept. Cargill Building Minneapolis, MN 55402	TEXTRATEIN, Minced, 11F	Uncolored	Unflavored
	TEXTRATEIN, Minced, 11BF	Caramel	Unflavored
	TEXTRATEIN, Minced, 24F	Uncolored	Unflavored
	TEXTRATEIN, Minced, 24BF	Caramel	Unflavored

II. Companies Producing and/or Distributing Under Private Label Acceptable Textured Vegetable Protein Product Mixes

Note: Textured vegetable protein product "mixes" combine textured vegetable protein with dehydrated vegetables, seasonings, bread crumbs or cereals. Only the textured vegetable protein component in the mix may be credited in the Type A lunch. Column 3 below gives the amount of textured vegetable protein in each mix. Yield information in column 4 is based on directions for use or specific recipes on individual mix product labels. " " indicate names of recipes as they appear on the label. The servings stated specify the number of servings of meat/mix combination equivalent to the specified amount of cooked lean meat that may be credited toward the meat/meat alternate requirement of the Type A lunch. The actual size of serving is larger than the equivalent amount of meat/meat alternate and should be stated on the individual product label.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Alberto-Culver Company 2525 Armitage Avenue Melrose Park, IL 60160	MILANI Base Mix with Textured Vegetable Protein	18.8% or 3-1/4 oz per 18 oz pkg. (net wt.)	"Directions": 49 2-ounce equivalent servings of meat/meat alternate per pkg. "Minuette of Beef": 49 2-ounce equivalent servings of meat/meat alternate per pkg. "DeLuxe Hamburger": 119 2-ounce equivalent servings of meat/meat alternate per pkg. "Economy Meat Loaves": 38 2-ounce equivalent servings of meat/meat alternate per pkg.
	MILANI Sloppy Joe Mix with Textured Vegetable Protein	55.88% or 26-3/4 oz per 48 oz pkg. (net wt.)	82 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the MILANI mixes is MIRA-TEX 240F or MIRA-TEX 210-2-F manufactured by A. E. Staley.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Bernard Food Industries, Inc. 1125 Hartrey Avenue P. O. Box 1497 Evanston, IL 60204	TEX-PRO ONE Meat Extender for Hamburger Patties	83.29% or 30 oz per 36 oz pkg. (net wt.)	"Directions to Yield a 19 lb. Loaf": 99 2-ounce equivalent servings of meat/meat alternate per pkg.
	TEX-PRO TWO for Preparing Meat Loaf	39.67% or 19 oz per 48 oz pkg. (net wt.)	"To Yield a 14 Pound Meat Loaf": 58 2-ounce equivalent servings of meat/meat alternate per pkg.
	TEX-PRO THREE Sloppy Joe Mix	58.4% or 30 oz per 52 oz pkg. (net wt.)	"To Prepare Over 4 Gallons Sloppy Joe Filling": 200 1-ounce equivalent servings of meat/meat alternate per pkg. "To Prepare 3 Gallons Meatless Sloppy Joe Filling" is NOT for School Lunch.
	TEX-PRO FOUR Chili Mix	47.45% or 22-3/4 oz per 48 oz pkg. (net wt.)	"Chili Con Carne with Beans" and "Corn Chip Chili Casserole": 150 2-ounce equivalent servings of meat/meat alternate per pkg. "Chili Mac": 75 2-ounce equivalent servings of meat/meat alternate and 1/4 cup servings of vegetable per pkg. "Deluxe Chili Mac": 100 2-ounce equivalent servings of meat/meat alternate and 1/4 cup servings of vegetable per pkg.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Bernard Food Industries, Inc. (continued)	TEX-PRO FIVE Taco Filling Mix	47.09% or 30 oz per 4 lb pkg. (net wt.)	"Directions to Prepare 25 lbs. Finished Taco Filling": 200 1-ounce equivalent servings of meat/meat alternate and 1/4 cup servings of vegetable per pkg.
			"Taco Dogs": 200 2-ounce equivalent servings of meat/meat alternate and a serving of bread per 1/2 pkg.
	TEX-PRO SIX Veal-Pork-Tuna & Salmon Patty Mix	74.48% or 35-3/4 oz per 48 oz pkg. (net wt.)	"Directions to Yield 232 One (1) Ounce Equivalent Meat/Meat Alternate Patties": 232 1-ounce equivalent servings of meat/meat alternate per pkg.
			"Directions to Yield 160 Half-Cup Servings of Protein-Rich Tuna Salad": 160 2-ounce equivalent servings of meat/meat alternate per 2/3 pkg.
	TEX-PRO SEVEN Spaghetti Sauce Mix	62.5% or 30 oz per 48 oz pkg. (net wt.)	"To Prepare Over 4 Gallons Protein Spaghetti Sauce with Meat": 200 1-ounce equivalent servings of meat/meat alternate per pkg.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Bernard Food Industries, Inc. (continued)	TEX-PRO SEVEN Spaghetti Sauce Mix (continued)		"To Prepare 3 Gallons Meatless Protein Spaghetti Sauce" is NOT for School Lunch.

Note: The textured vegetable protein component of the Bernard mixes is TVP, minced 180, fortified, color C and uncolored manufactured by Archer Daniels Midland, or MIRA-TEX 220-F and 220-1-F manufactured by A. E. Staley.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Biggers Brothers, Inc. P. O. Box 2356 2800 South Boulevard Charlotte, NC 28201	FARMBEST School Lunch Chili Mix & Textured Vegetable Protein	42.06% or 17-3/4 oz per 2 lb 10 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	FARMBEST School Lunch Meat Loaf/Meat Ball Mix & Textured Vegetable Protein	48.93% or 20 oz per 2 lb 9 oz pkg. (net wt.)	84 2-ounce equivalent servings of meat/meat alternate per pkg.
	FARMBEST School Lunch Patty Mix & Textured Vegetable Protein	83.03% or 30-1/4 oz per 2 lb 4-1/2 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	FARMBEST School Lunch Pizza Sauce Mix & Textured Vegetable Protein	55% or 17-1/2 oz per 2 lb pkg. (net wt.)	112 2-ounce equivalent servings of meat/meat alternate per pkg.
	FARMBEST School Lunch Sloppy Joe Mix & Textured Vegetable Protein	52.13% or 28-3/4 oz per 3 lb 7 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	FARMBEST School Lunch Spaghetti Sauce Mix & Textured Vegetable Protein	46.58% or 16-3/4 oz per 2 lb 4 oz pkg. (net wt.)	100 1-ounce equivalent servings of meat/meat alternate per pkg.
	FARMBEST School Lunch Taco Mix & Textured Vegetable Protein	61.82% or 24-3/4 oz per 2 lb 8 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the FARMBEST mixes is GL-219, PROMATE #500-SL or PROMATE #100-SL manufactured by Griffith.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Continental Organization of Distributor Enterprises, Inc. Suite 602 Manor Oak Two 1910 Cochran Road Pittsburgh, PA 15220	CODE School Lunch Chili Mix & Textured Vegetable Protein	42.06% or 17-3/4 oz per 2 lb 10 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	CODE School Lunch Meat Loaf/ Meat Ball Mix & Textured Vegetable Protein	48.93% or 20 oz per 2 lb 9 oz pkg. (net wt.)	84 2-ounce equivalent servings of meat/meat alternate per pkg.
	CODE School Lunch Patty Mix & Textured Vegetable Protein	83.03% or 30-1/4 oz per 2 lb 4-1/2 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	CODE School Lunch Pizza Sauce Mix & Textured Vegetable Protein	55% or 17-1/2 oz per 2 lb pkg. (net wt.)	112 2-ounce equivalent servings of meat/meat alternate per pkg.
	CODE School Lunch Sloppy Joe Mix & Textured Vegetable Protein	52.13% or 28-3/4 oz per 3 lb 7 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	CODE School Lunch Spaghetti Sauce Mix & Textured Vegetable Protein	46.58% or 16-3/4 oz per 2 lb 4 oz pkg. (net wt.)	100 1-ounce equivalent servings of meat/meat alternate per pkg.
	CODE School Lunch Taco Mix & Textured Vegetable Protein	61.82% or 24-3/4 oz per 2 lb 8 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the CODE mixes is GL-219, PROMATE #500-SL or PROMATE #100-SL manufactured by Griffith.

Federated Foods, Inc. 2250 East Devon Avenue Des Plaines, IL 60018	RED & WHITE or PARADE School Lunch Chili Mix & Textured Vegetable Protein	42.06% or 17-3/4 oz per 2 lb 10 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.

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COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Federated Foods, Inc. (continued)	RED & WHITE or PARADE School Lunch Meat Loaf/Meat Ball Mix & Textured Vegetable Protein	48.93% or 20 oz per 2 lb 9 oz pkg. (net wt.)	84 2-ounce equivalent servings of meat/meat alternate per pkg.
	RED & WHITE or PARADE School Lunch Patty Mix & Textured Vegetable Protein	83.03% or 30-1/4 oz per 2 lb 4-1/2 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	RED & WHITE or PARADE School Lunch Pizza Sauce Mix & Textured Vegetable Protein	55% or 17-1/2 oz per 2 lb pkg. (net wt.)	112 2-ounce equivalent servings of meat/meat alternate per pkg.
	RED & WHITE or PARADE School Lunch Sloppy Joe Mix & Textured Vegetable Protein	52.13% or 28-3/4 oz per 3 lb 7 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	RED & WHITE or PARADE School Lunch Spaghetti Sauce Mix & Textured Vegetable Protein	46.58% or 16-3/4 oz per 2 lb 4 oz pkg. (net wt.)	100 1-ounce equivalent servings of meat/meat alternate per pkg.
	RED & WHITE or PARADE School Lunch Taco Mix & Textured Vegetable Protein	61.82% or 24-3/4 oz per 2 lb 8 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the RED & WHITE and PARADE mixes is GL-219, PROMATE #500-SL or PROMATE #100-SL manufactured by Griffith.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Kraft Foods 500 Peshtigo Court Chicago, Illinois 60690	KRAFT School Lunch Chili Mix & Textured Vegetable Protein	42.06% or 17-3/4 oz per 2 lb 10 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	KRAFT School Lunch Sloppy Joe Mix & Textured Vegetable Protein	52.13% or 28-3/4 oz per 3 lb 7 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the KRAFT mixes is PROMATE #500-SL or PROMATE #100-SL manufactured by Griffith.

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COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Lawry's Foods, Inc. 568 San Fernando Road Los Angeles, CA 90065	LAWRY's STRETCH Taco Filling Mix	54.30% or 39 oz per 4-1/2 lb pkg. (net wt.)	76 2-ounce equivalent servings of meat/meat alternate per 1/2 pkg.

Note: The textured vegetable protein component of the LAWRY mix is ULTRA-SOY (F) manufactured by Far-Mar-Co.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Milwaukee Seasoning Laboratories, Inc. 2803 North 32nd Street Milwaukee, WI 53210	MSL TVP PATTY MIX #1118	85% or 17 lb per 20 lb pkg. (net wt.)	1649 2-ounce equivalent servings of meat/meat alternate per pkg.
	FLAVORMATE Complete School Lunch Beef & Patty Mix #1526	85% or 11 lb per 13 lb pkg. (net wt.)	570 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the Milwaukee Seasoning mixes is TEXRATEIN #18F manufactured by Cargill, TVP fortified manufactured by Archer Daniels Midland or BONTRAE unflavored crumbles manufactured by General Mills.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
National Institutional Food Distributor Associates, Inc. P. O. Box 19936, Station N Atlanta, GA 30325	NIFDA School Lunch Chili Mix & Textured Vegetable Protein	42.06% or 17-3/4 oz per 2 lb 10 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	NIFDA School Lunch Meat Loaf/ Meat Ball Mix & Textured Vegetable Protein	48.93% or 20 oz per 2 lb 9 oz pkg. (net wt.)	84 2-ounce equivalent servings of meat/meat alternate per pkg.
	NIFDA School Lunch Patty Mix & Textured Vegetable Protein	83.03% or 30-1/4 oz per 2 lb 4-1/2 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	NIFDA School Lunch Pizza Sauce Mix & Textured Vegetable Protein	55% or 17-1/2 oz per 2 lb pkg. (net wt.)	112 2-ounce equivalent servings of meat/meat alternate per pkg.
	NIFDA School Lunch Sloppy Joe Mix & Textured Vegetable Protein	52.13% or 28-3/4 oz per 3 lb 7 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	NIFDA School Lunch Spaghetti Sauce Mix & Textured Vegetable Protein	46.58% or 16-3/4 oz per 2 lb 4 oz pkg. (net wt.)	100 1-ounce equivalent servings of meat/meat alternate per pkg.
	NIFDA School Lunch Taco Mix & Textured Vegetable Protein	61.82% or 24-3/4 oz per 2 lb 8 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the NIFDA mixes is GL-219, PROMATE #500-SL or PROMATE #100-SL manufactured by Griffith.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
National School-Pak 1415 West 37th Street Chicago, IL 60609	NATIONAL SCHOOL-PAK School Lunch Chili Mix & Textured Vegetable Protein	42.06% or 17-3/4 oz per 2 lb 10 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	NATIONAL SCHOOL-PAK School Lunch Meat Loaf/Meat Ball Mix & Textured Vegetable Protein	48.93% or 20 oz per 2 lb 9 oz pkg. (net wt.)	84 2-ounce equivalent servings of meat/meat alternate per pkg.
	NATIONAL SCHOOL-PAK School Lunch Patty Mix & Textured Vegetable Protein	83.03% or 30-1/4 oz per 2 lb 4-1/2 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	NATIONAL SCHOOL-PAK School Lunch Pizza Sauce Mix & Textured Vegetable Protein	55% or 17-1/2 oz per 2 lb pkg. (net wt.)	112 2-ounce equivalent servings of meat/meat alternate per pkg.
	NATIONAL SCHOOL-PAK School Lunch Sloppy Joe Mix & Textured Vegetable Protein	52.13% or 28-3/4 oz per 3 lb 7 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	NATIONAL SCHOOL-PAK School Lunch Spaghetti Sauce Mix & Textured Vegetable Protein	46.58% or 16-3/4 oz per 2 lb 4 oz pkg. (net wt.)	100 1-ounce equivalent servings of meat/meat alternate per pkg.
	NATIONAL SCHOOL-PAK School Lunch Taco Mix & Textured Vegetable Protein	61.82% or 24-3/4 oz per 2 lb 8 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the NATIONAL SCHOOL-PAK mixes is GL-219, PROMATE #500-SL or PROMATE #100-SL manufactured by Griffith.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
North American Laboratory Co., Inc. 1717 W. 10th Street Indianapolis, IN 46206	MENU MAGIC MEAT TWIN or MEAT TWIN V	88.89% or 2 lb per 2 lb 4 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	MENU MAGIC Chili Seasoning	47.33% or 22-3/4 oz per 2 lb 2 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	MENU MAGIC Meat Loaf and Meat Ball Seasoning	62.75% or 2 lb per 3 lb 3 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
North American Laboratory Co., Inc. (continued)	MENU MAGIC Pizza Burger Seasoning	63.77% or 26-3/4 oz per 2 lb 10 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	MENU MAGIC Sloppy Joe Seasoning	62.75% or 2 lb per 3 lb 4 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	MENU MAGIC Spaghetti Sauce Seasoning	49.56% or 31-1/2 oz per 4 lb pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	MENU MAGIC Taco Seasoning	80% or 2 lb per 2 lb 8 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the MENU MAGIC mixes is VMR II, uncolored manufactured by Nabisco or TVP, minced 180, fortified, color C manufactured by Archer Daniels Midland.

Nugget Distributors, Inc. P. O. Box 8309 Stockton, CA 95204	NUGGET School Lunch Chili Mix & Textured Vegetable Protein	42.06% or 17-3/4 oz per 2 lb 10 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	NUGGET School Lunch Meat Loaf/Meat Ball Mix & Textured Vegetable Protein	48.93% or 20 oz per 2 lb 9 oz pkg. (net wt.)	84 2-ounce equivalent servings of meat/meat alternate per pkg.
	NUGGET School Lunch Patty Mix & Textured Vegetable Protein	83.03% or 30-1/4 oz per 2 lb 4-1/2 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	NUGGET School Lunch Pizza Sauce Mix & Textured Vegetable Protein	55% or 17-1/2 oz per 2 lb pkg. (net wt.)	112 2-ounce equivalent servings of meat/meat alternate per pkg.
	NUGGET School Lunch Sloppy Joe Mix & Textured Vegetable Protein	52.13% or 28-3/4 oz per 3 lb 7 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	NUGGET School Lunch Spaghetti Sauce Mix & Textured Vegetable Protein	46.58% or 16-3/4 oz per 2 lb 4 oz pkg. (net wt.)	100 1-ounce equivalent servings of meat/meat alternate per pkg.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Nugget Distributors, Inc. (continued)	NUGGET School Lunch Taco Mix & Textured Vegetable Protein	61.82% or 24-3/4 oz per 2 lb 8 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the NUGGET mixes is GL-219, PROMATE #500-SL or PROMATE #100-SL manufactured by Griffith.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Sysco Corporation Capital National Bank Building Suite 800 1300 Main Street Houston, TX 77002	SYSCO School Lunch Chili Mix & Textured Vegetable Protein	42.06% or 17-3/4 oz per 2 lb 10 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.
	SYSCO School Lunch Meat Loaf/Meat Ball Mix & Textured Vegetable Protein	48.93% or 20 oz per 2 lb 9 oz pkg. (net wt.)	84 2-ounce equivalent servings of meat/meat alternate per pkg.
	SYSCO School Lunch Patty Mix & Textured Vegetable Protein	83.03% or 30-1/4 oz per 2 lb 4-1/2 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	SYSCO School Lunch Pizza Sauce Mix & Textured Vegetable Protein	55% or 17-1/2 oz per 2 lb pkg. (net wt.)	112 2-ounce equivalent servings of meat/meat alternate per pkg.
	SYSCO School Lunch Sloppy Joe Mix & Textured Vegetable Protein	52.13% or 28-3/4 oz per 3 lb 7 oz pkg. (net wt.)	99 2-ounce equivalent servings of meat/meat alternate per pkg.
	SYSCO School Lunch Spaghetti Sauce Mix & Textured Vegetable Protein	46.58% or 16-3/4 oz per 2 lb 4 oz pkg. (net wt.)	100 1-ounce equivalent servings of meat/meat alternate per pkg.
	SYSCO School Lunch Taco Mix & Textured Vegetable Protein	61.82% or 24-3/4 oz per 2 lb 8 oz pkg. (net wt.)	100 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the SYSCO mixes is GL-219, PROMATE #500-SL or PROMATE #100-SL manufactured by Griffith.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
Williams Foods, Inc. 1900 West 47th Place Westwood, KS 66205	WILLIAMS EXPAND Textured Vegetable Protein with Chili Seasoning	81.25% or 26 oz per 2 lb pkg. (net wt.)	119 2-ounce equivalent servings of meat/meat alternate per pkg.
	WILLIAMS EXPAND Textured Vegetable Protein with Meat Loaf Seasoning	63.41% or 26 oz per 2 lb 9 oz pkg. (net wt.)	80 2-ounce equivalent servings of meat/meat alternate per pkg.
	WILLIAMS EXPAND Textured Vegetable Protein with Patty Seasoning	63.41% or 26 oz per 2 lb 9 oz pkg. (net wt.)	83 2-ounce equivalent servings of meat/meat alternate per pkg.
	WILLIAMS EXPAND Textured Vegetable Protein with Sloppy Joe Seasoning	63.41% or 26 oz per 2 lb 9 oz pkg. (net wt.)	83 2-ounce equivalent servings of meat/meat alternate per pkg.
	WILLIAMS EXPAND Textured Vegetable Protein with Spaghetti Sauce Mix	63.41% or 26 oz per 2 lb 9 oz pkg. (net wt.)	83 2-ounce equivalent servings of meat/meat alternate per pkg.
	WILLIAMS EXPAND Textured Vegetable Protein with Taco Seasoning	63.41% or 26 oz per 2 lb 9 oz pkg. (net wt.)	83 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The textured vegetable protein component of the WILLIAMS EXPAND mixes is ULTRA-SOY (F) manufactured by Far-Mar-Co or TEXTRATEIN F manufactured by Cargill.

COMPANY	PRODUCT	% TEXTURED VEGETABLE PROTEIN COMPONENT IN MIX	YIELD INFORMATION FOR RECIPE(S) ON LABEL
The Golden Dipt Company Division of DCA Food Industries, Inc. 100 E. Washington Street Millstadt, IL 62260	GOLDEN DIPT/DCA CHILI MATE, Fortified Textured Vegetable Protein with Chili Seasoning	81.25% or 26 oz per 2 lb pkg. (net wt.)	83 2-ounce equivalent servings of meat/meat alternate per pkg.
	GOLDEN DIPT/DCA MEAT LOAF MATE, Fortified Textured Vegetable Protein with Meat Loaf Seasoning	63.41% or 26 oz per 2 lb 9 oz pkg. (net wt.)	80 2-ounce equivalent servings of meat/meat alternate per pkg.
	GOLDEN DIPT/DCA HAMBURGER MATE, Fortified Textured Vegetable Protein with Patty Seasoning	63.41% or 26 oz per 2 lb 9 oz pkg. (net wt.)	83 2-ounce equivalent servings of meat/meat alternate per pkg.
	GOLDEN DIPT/DCA SLOPPY JOE MATE, Fortified Textured Vegetable Protein with Sloppy Joe Seasoning	63.41% or 26 oz per 2 lb 9 oz pkg. (net wt.)	83 2-ounce equivalent servings of meat/meat alternate per pkg.
	GOLDEN DIPT/DCA SPAGHETTI MATE, Fortified Textured Vegetable Protein with Spaghetti Sauce Mix	63.41% or 26 oz per 2 lb 9 oz pkg. (net wt.)	83 2-ounce equivalent servings of meat/meat alternate per pkg.
	GOLDEN DIPT/DCA TACO MATE, Fortified Textured Vegetable Protein with Taco Seasoning	63.41% or 26 oz per 2 lb 9 oz pkg. (net wt.)	83 2-ounce equivalent servings of meat/meat alternate per pkg.

Note: The GOLDEN DIPT/DCA mixes are identical to the corresponding mixes manufactured by Williams Foods, Inc.

FAR-MAR-CO edible soy processing plant located in St. Joseph, Missouri.

FARMER COOPERATIVE SERVICE
U.S. DEPARTMENT OF AGRICULTURE

Farmer Cooperative Service provides research, management, and educational assistance to cooperatives to strengthen the economic position of farmers and other rural residents. It works directly with cooperative leaders and Federal and State agencies to improve organization, leadership, and operation of cooperatives and to give guidance to further development.

The Service (1) helps farmers and other rural residents obtain supplies and services at lower cost and to get better prices for products they sell; (2) advises rural residents on developing existing resources through cooperative action to enhance rural living; (3) helps cooperatives improve services and operating efficiency; (4) informs members, directors, employees, and the public on how cooperatives work and benefit their members and their communities; and (5) encourages international cooperative programs.

The Service publishes research and educational materials and issues *News for Farmer Cooperatives*. All programs and activities are conducted on a nondiscriminatory basis, without regard to race, creed, color, sex, or national origin.

INDUSTRIAL PRODUCTION AND SELLING PRICES OF EDIBLE SOYBEAN PROTEIN PRODUCTS

The following table gives estimates of U.S. production of soy flours, concentrates, isolates plus textured flours and concentrates for 1976. Soy flours are the predominant form produced and sell at the lowest price of the five protein types. Concentrates and isolates are manufactured at about one-eighth the scale for the flours but sell at more than 2-5 times the price paid for flours. Flours are the major form used for preparation of textured items. Textured concentrates were introduced in 1975 and, consequently, have not developed a large market yet.

Protein form	Protein content (%)	Selling price per lb (cents)	Annual production (estimated) (million lb)
Flours	50	14	625
Concentrates	70	32-35	80
Isolates	90	72-75	75
Textured flours	50	22	120-130
Textured concentrates	70	33-35	4-5

Source: N. R. Lockmiller (1976) personal communication.

BARRIERS TO ACCEPTABILITY AND UTILIZATION OF SOYBEANS IN FOOD AND RESEARCH RECOMMENDATIONS

BARRIERS TO ACCEPTABILITY AND UTILIZATION OF SOYBEANS IN FOOD

Introduction of a new food in any country is a difficult task and a number of hurdles must be overcome if such a venture is to be successful. Some of the major factors likely to influence the introduction of soybeans into the diet of a developing country are itemized below.

Availability

Soybeans must be available through imports or local production. Local production is preferable and ideally soybeans should be available at a cost below that of other legumes for which soybeans may be substituted.

Cultural and Social Factors

Soybeans consumed directly in family meals have been the subject of a wide number of publications in the form of books and manuals presenting simple-to-follow cooking recipes. However, the main and critical deterrent to the food use of soybeans is cultural background. Except for the Far Eastern countries, food use of soybeans is new to the cultures of most peoples of the world. Social taboos can be a major hindrance to the food consumption of soybeans. For example, soybeans have sometimes been called "a poor man's food" or "animal feed." When this occurs, it becomes extremely difficult to promote soybean foods to the poor undernourished populations where the need is greatest. In some countries, such as Mexico, it has been possible to promote soybean foods to the affluent class to establish a favorable class image before introducing them to

the poor. The cultural situation must be assessed carefully in selecting possible methods for integrating the soybean into the traditional or indigenous foods of a given country.

Texture

The whole soybean is the simplest form for introduction directly into the diet, but like other legumes, soybeans must be cooked before eating. Unlike legumes such as peas and beans, soybeans are more difficult to cook and texture of cooked soybeans differs from that of other legumes. Difficulties in cooking to a desirable texture is a complaint cited by many who have attempted to develop simple processes for food use of soybeans in various countries (Final Report on Contract AID/CM/ta-c-73-19, University of Illinois). If soybeans are converted into flours and added to foods, texture may also be influenced adversely. For example, replacement of wheat flour in bread with soy flour results in undesirable textural changes which can be overcome only by adding special emulsifiers.

Flavor

Soybeans in their raw state have characteristic beany and bitter flavors that make them unpalatable. These flavors are decreased significantly by cooking and other processing but residual flavors are often still objectionable. In many of the Oriental soybean food products, the flavor problem has been overcome by fermentation to develop new flavors and destroy objectionable ones. Although acceptable to many of the Eastern populations, such flavors are foreign to many others and may be unacceptable.

Nutrition and Food Safety

In any program introducing soybean as a food, nutritional quality plays an important role. Much has been published about the destruction of nutritional factors during heat treatment or processing of soybeans. Antinutritional and physiological factors in raw and improperly processed soybean products have been a barrier to utilization particularly where soy has replaced a food of proven high nutritional properties such as milk, meat, or eggs. Developing new processes, whether for the simple village level or for larger-scale commercial application, will require careful study to ascertain that maximum nutritional properties of soy protein are developed and maintained during each of the process steps.

Food safety also must be maintained in the processing. Otherwise, this becomes a serious barrier to its use. Particular attention must be paid to the quality of the soybeans used as a raw material as related to storage problems and development of bacteria and mold toxins. Soybeans in storage must be protected from insects and rodents. Soybeans must be handled to minimize breakage, since broken beans are more subject to mold and bacterial attack and nonuniformity in cooking. During processing, especially if high moisture and temperatures prevail over lengthy periods (aqueous systems), bacteria can be a big problem with soy proteins and may lead to contaminated products unfit for human feeding.

Technology Development

As summarized in this report, there is a wide variety of relatively simple technology available for introducing soybeans into the diet. Nonetheless, many of these processes may be unsuited in a given country for a number of reasons. For example, there may be a scarcity of fuel, hence, the usual long cooking times required for soybeans would be unacceptable. There is, therefore, a continuing need for alternate technologies for incorporating soybeans into the diet in different countries. This can consist of new processes and modification of available technologies to suit a local situation.

Technology Transfer

Even with the availability of a variety of technologies for using soybeans in foods, many problems are encountered in attempting to transfer them to a foreign country. Developing the technology is only a first step. Successful promotion of a methodology requires immediate follow-up by setting up a program in the field to train local groups to produce soybean food products and then to use them in the native diets. Feedback from the local groups to the original process developers is of utmost importance so that process modification can be made to better fit the field situations if necessary. Promotional efforts would be aided by communication between all parties involved. Lack of information exchange in the past has resulted in little or no progress and in duplication of efforts by different groups.

RESEARCH RECOMMENDATIONS

Cultural and Social Factors

Because of their critical role in the acceptance or rejection of new or modified foods, cultural and social factors such as local diets, food preferences, and food purchasing patterns must be carefully evaluated. We recommend that soybeans be used by adding them to existing native foods in a particular country rather than by promoting soybean products as totally new foods. Introduction of a new and strange food is almost certain to be a failure because of cultural biases. Ideally, the soybean products should be consumed in native foods that are eaten by all social classes and at most meals (e.g., tortillas in Mexico).

Soybeans can be converted into different forms that are adaptable for incorporation into a wide variety of foods. These forms include the following:

(a) Whole soybeans. This is the most direct and efficient use of soybeans. Use of whole cooked soybeans may be feasible in diets where other legumes are used in the same manner. Alternatively, the cooked soybeans may be ground and incorporated into another product. An example, of this approach is the cooking of whole soybeans with corn in limewater followed by grinding into a masa for making enriched tortillas as described by Mexican workers.

(b) Full-fat flours. Simple village methods are available for preparation of these products which can be incorporated into a wide variety of indigenous foods such as baked goods, gruels, soups, noodles, and beverages.

(c) Oriental soybean foods. Products such as soybean curd, soybean milk, and tempeh are made by simple processes and require no elaborate equipment. These products are versatile and it should be possible to develop recipes for incorporating them into native cuisines.

Texture

Because of the frequent complaint that soybeans are difficult to cook to a degree of tenderness desired for a cooked legume, there is a need for research on methods for shortening the cooking time. Soaking of lima beans in salt mixtures prior to cooking markedly cuts down the time required for cooking to desired tenderness [Food Technol. 21: 344 (1967]. Limited studies also confirmed that soybeans require cooking for 6-7 times as long as needed for lentils and lima beans. Moreover, use of the salt mixtures likewise reduced cooking times for soybeans. The salt mixture consisted of sodium chloride, sodium tripolyphosphate, sodium bicarbonate, and sodium carbonate. This salt mixture may be too complex and expensive for use in a developing country, but less complicated and more readily available salt mixtures may also be suitable. Other approaches such as cracking the soybeans prior to cooking should also be examined if there is no objection to a broken bean after cooking.

Studies are needed to identify factors responsible for slow cooking of soybeans in order to provide a physical and chemical basis for developing new processes for shortening cooking time. Use of salt solutions, although partially successful, is based primarily on empirical observations. An understanding of the relationship between seed structure, chemical composition, and texture would likely suggest new ways to speed up cooking of soybeans.

Flavor

The technologies for improving flavor of soybeans are well documented in the literature. However, in the final analyses, the food product itself dictates the degree of processing required. If the product is used as a highly seasoned or spiced food as in Latin American foods, for example, a limited amount of heat treatment or toasting will improve the flavor sufficiently to make it entirely acceptable. If, however, soy protein is to be used in bland products such as milks or soy milk curds, the soy protein needs to be as free of grassy-beany flavors as possible.

Some of the Oriental processes such as for tofu and miso use carefully worked out methods to remove off-flavors and even include fermentation to develop delicate and acceptable flavors in the soy protein products. In considering flavor improvement, therefore, one needs to consider the final food product and then work back to develop an acceptable flavor threshold which will fit the culinary tastes normally customary or associated with a native food.

Foods that have soybeans incorporated into them should be carefully evaluated by submitting them to native groups to be certain that flavors are acceptable before attempting to promote the same foods on a large scale. Association of poor flavor with soy in a given food may make it difficult to obtain acceptance of other foods containing soy even when no flavor problem exists because of previous prejudices developed against soybeans.

<u>Nutrition and Food Safety</u>

Incorporation of soybeans into the diet of a less developed country should be accompanied by nutritional studies to demonstrate the beneficial effects of soybean proteins and to ensure that no untoward reactions occur because of interactions with other dietary constituents. Developing new processes, whether for the village level or for large-scale commercial application, will require careful study to ascertain that maximum nutritional properties of the soy proteins are developed and maintained in the form that is finally consumed. Research is needed to show that food items containing soybeans are not contaminated by microorganisms that may produce toxins, particularly if environmental conditions are conducive for microorganism growth during food preparation.

<u>Technology Development</u>

In spite of the various methods and technologies already available for incorporating soybeans into the human diet, it is likely that they may not be adequate in a given country. Further technology will thus be needed; this may consist of developing a new technology or modifying an existing one to suit local conditions. For example, present village

processes for producing full-fat soy flours need to be modified to make them adaptable to areas of high humidity where poor outdoor drying conditions exist. In the preparation of tempeh, there is a need for a starter culture to innoculate the cooked beans. The technology for making such a starter has been developed at the Northern Regional Research Center, but it is likely that modifications would be necessary to adapt it to a specific country.

Technology Transfer

Successful introduction of soybeans into native foods of developing countries will require an extensive program including governmental information campaigns, teaching of good nutritional practices, transfer and implementation of technologies at the home and village level, development of suitable recipes, and promotion of recipe use.

A major problem in the past with the various programs designed to introduce food uses of soybeans in developing countries has been a lack of overall coordination and feedback of information between researchers in the laboratory who are developing a technology and workers out in the field who are attempting to transfer the technology. We recommend that overall responsibility for overseeing introduction of soybean foods in developing countries be assigned to a single organization such as the Agricultural Research Service of USDA. Such an organization has expertise in science, technology, sociology, home economics, and communications. Responsibility of overseeing the development should include provision of a central clearing house of scientific and technological information on soybean usage in developed and developing countries.

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